



**UiO : University of Oslo**

**FYS3240- 4240**

**Data acquisition & control**

# **Exam preparations**

**Spring 2026**



Bekkeng 14.05.2026

# Oral Exam

- 3rd June & 4th June
- Oral examination
- 30 minutes examination

## Curriculum FYS3240 & FYS4240

### Lecture notes

Slides marked with **Extra** (in the top right corner) are not part of the curriculum (only for information).

### Laboratory exercises

- Lab 1 – 4 for FYS3240
- Lab 1 – 5 for FYS4240

### Reference papers:

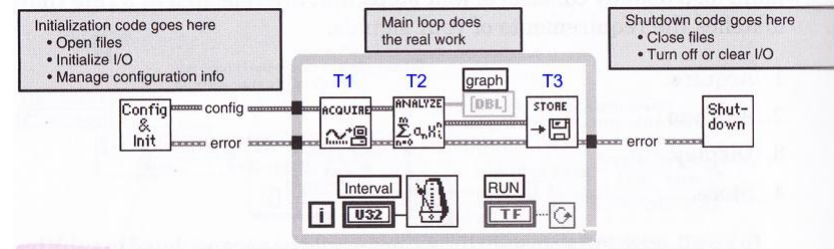
- Stochastic models, estimation and control (by Maybeck)
- An Introduction to the Kalman Filter (by Welch and Bishop)
  - Section 1 and section 3

**Questions you should be able to  
answer and discuss on the exam**

# LabVIEW

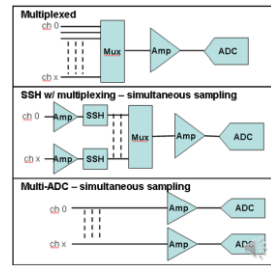
- Note: you will not be asked to do LabVIEW programming with pen and paper, but you can be asked to explain a simple LabVIEW code.
- Can you list three advantages of using LabVIEW for data acquisition?
- Explain dataflow programming in LabVIEW
- Does LabVIEW support parallel programming (multithreading) ? Explain how.
- How can we synchronize two loops running in parallel ?
- Why us / not use Express VIs ?
- What is a sub-VI?
- What is a cluster in LabVIEW? List some advantages of using it and explain the difference between clusters and arrays.
- Why should we in general avoid/limit the use of local and global variables and instead use wires on the diagram/between sub-VIs?
- How do you compile a LabVIEW program ?

# LabVIEW II



- Why use shift registers in the LabVIEW code ? How to add ?
- Why use state machines, and how to make it in LabVIEW code?
- Describe the architecture for a sequential DAQ design, and the problems associated with using such an architecture.
- Explain the producer-consumer architecture and why it is used.
- Why use queues (not local/global variables) to send data and messages between while-loops ? Explain queues!
- What is the advantage of using the DAQ Assistant (express VI) ?
- Why can it be very useful to be able to simulate a DAQ card ? How can we do this easily when using LabVIEW ?
- **FYS4240 only:** Explain the Queued Message Handler (QMH) template / architecture, based on lab 5.
  - Why should we use this ?

# Analog front-end electronics & sampling



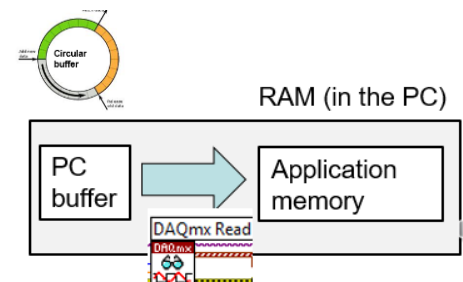
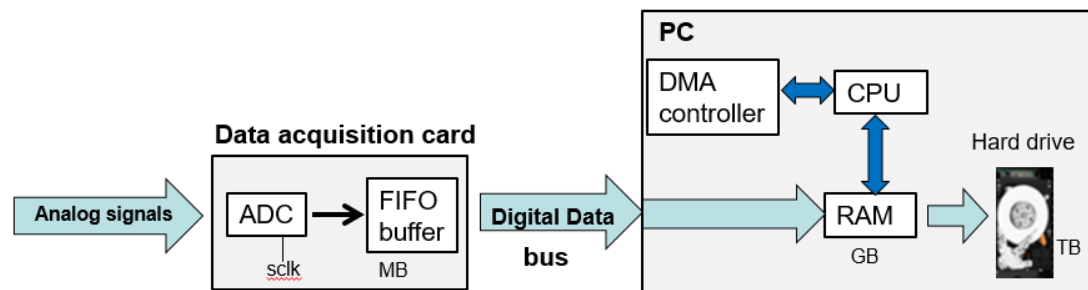
- What happens if your DAQ input impedance is too low?
- Explain single-ended vs. differential signals and their use.
- Explain typical signal conditioning required before A/D-conversion.
- Explain sampling and anti-aliasing
  - Nyquist
  - Oversampling – including advantages of using it
  - Why is an analog filter usually required before the ADC in a DAQ-system?
- Explain ADC architectures and ADC errors

# Computer buses and interfaces

- Explain the difference between synchronous and asynchronous serial data communication.
- Explain the RS232 protocol.
- Explain differences & advantages of RS422/485 vs RS232.
- You should be able to briefly explain SPI & I2C.
- Explain UDP and give examples of typical use.
- How can we send sensor data to multiple computers on the network ?
- What can a Windows Virtual Serial Ports (Virtual COM port) be used for ?
- What is a jumbo frame, and why use it?
- What is Manchester encoding and why use it or similar types of encoding?
  - Does the encoding affect the data bandwidth (number of actual data bits transmitted per second)? Explain.

# PC-based data acquisition

- Explain Interrupts vs. DMA
- What is hardware acceleration ?
- Explain data transfer from DAQ-card to hard drive/solid-state drive
- Why are buffers used, what types and where?
  - Hints: Circular buffer (PC buffer), FIFO buffer, overwrite and overflow errors
- **How to increase the signal-to-noise-ratio in a DAQ-system?**
- Why use averaging of data samples ?
- File types – advantages, write speed, file size
- What is Unbuffered File I/O and why (possibly) use it?
- What would be the advantages/disadvantages of sending/storing raw data (integer values) instead of converting to floating point values first?



# PC-based data acquisition II

- Explain the use of Start trigger and Reference (event) trigger.
- Why use circular buffers in video acquisition ?
- You are told to make a file format to store video data. Can you suggest a structure and explain your choices.
- How would you store time stamps in your file ? Explain
- Can you give an example of data instability, and how you can avoid this problem ?
- Can you give an example of a distributed application ? How can you implement this ?

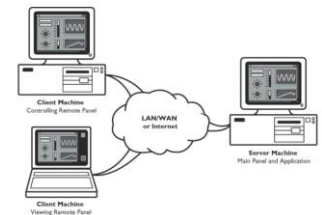


Figure 1: Distributed Application

# Timestamping and synchronization (DAQ)

- Explain software timing vs. hardware timing.
- What are the general problems with software timing (using the PC clock) ?
- What can we do if we need an accurate crystal oscillators for our electronics?
  - Hint: XO vs TCXO vs CSAC
- Explain how the computer clock (PC clock) works and its limitations
  - RTC
  - Software clock
  - drift
- List and explain briefly different time codes/protocols that can be used for synchronization
  - IRIG-B
  - IEEE 1588 (PTP)
  - NTP
- Know roughly what kind of timing accuracy we can obtain with different technologies (time codes/protocols)
  - Seconds (s), ms,  $\mu$ s or ns range.
  - Are they dependent on range/network complexity ?

# Arduino

- Explain this code...

It is expected that you understand (and can write) basic code for Arduino.

```
#include <Arduino_LSM9DS1.h>

void setup() {
  Serial.begin(9600);
  while (!Serial);
  Serial.println("Started");

  if (!IMU.begin()) {
    Serial.println("Failed to initialize IMU!");
    while (1);
  }

  Serial.print("Accelerometer sample rate = ");
  Serial.print(IMU.accelerationSampleRate());
  Serial.println(" Hz");
  Serial.println();
  Serial.println("Acceleration in G's");
  Serial.println("X\tY\tZ");
}

void loop() {
  float x, y, z;

  if (IMU.accelerationAvailable()) {
    IMU.readAcceleration(x, y, z);

    Serial.print(x);
    Serial.print('\t');
    Serial.print(y);
    Serial.print('\t');
    Serial.println(z);
  }
}
```

# Arduino II – General questions

- What is the advantage of sending sensor data from the Arduino board to the PC as text (ASCII) strings ?
- What is in general the disadvantage of sending sensor data as text (ASCII) strings ?
  - And what could we do instead?
- What is the **JSON** protocol, and why use it or not use it?
  - Hint: Self Descriptive protocol

# Data processing

- Explain real-time processing (online) vs. post-processing (off-line).
- Why use a zero-phase digital filter and when can it be used?
- What can be the problems of using a simple (moving) average filter ?
  - Suggest other possible filters
- How can we measure the phase between signals ?

# Reference frames and attitude

- What is an inertia reference frame ?
- Explain definitions of reference frames
  - ECEF, ECI, Body, Local level (NED and ENU), Sensor frame
- When do we have to consider the rotation of the Earth ?
  - With other words, when can we not say that ECI (i-frame) can be approximated with ECEF (e-frame)?
  - Hint: remember “low and slow”
- How can we represent an object’s orientation (attitude) ?
  - DCM, Euler angles
- Why is it important to know orientation (attitude) ?
  - Give some examples
- What do we mean with heading (definition) ?
- Can we use the gravity vector alone to determine heading ?
- How can we find the heading of a device or vehicle ?
- Explain a method to calibrate a magnetometer.

$$\mathbf{a}^i = R^{ie} \left( \mathbf{a}^e + \underbrace{2\boldsymbol{\Omega}^{ei} \mathbf{v}^e}_{\text{Coriolis acceleration}} + \underbrace{\boldsymbol{\Omega}^{ei} \boldsymbol{\Omega}^{ei} \mathbf{r}^e}_{\text{centripetal acceleration}} \right)$$

# Inertial navigation

- Explain the principles of inertial navigation
- What is an IMU and an INS ?
- What does an accelerometer measure?
  - Hint: **f**
  - When static
  - When in motion
  - When in free fall (in vacuum)
- How can we measure the tilt angle(s) of a device or platform ?
  - any limitations of the described method ?

# Inertial navigation II

- Explain typical systematic errors
- Explain typical random errors
- What are typical errors that we need to include in a model of a gyroscope?
- What is the effect of an uncompensated bias error in the gyroscope and accelerometer, when used in an INS?
- How does the INS position error change with time (how fast) ?
- Explain a method to calibrate an accelerometer.
- Explain a method to calibrate a rate gyroscope

# Data fusion & estimation

- What is estimation/data fusion?
- Why do we need an estimator?
- What are the advantages of multi-sensor data fusion?
- What is the Kalman filter (KF), and how does it work?
  - You should understand the principles (and how the equations work).
- Given the Kalman filter equations, explain the equations.
- How does the KF compare to the least squares technique?
- Explain two simpler alternatives to the Kalman filter
  - Alpha filter
  - Complimentary filtering

# Control systems

- Linear vs. nonlinear control
  - What can simple bang-bang (on/off) controllers be used for?
  - Why add hysteresis?
- Explain open loop vs. closed loop control
  - Be able to give at least one example of each
  - When (examples) is a closed-loop (feedback) controller needed ?
- Give an example of sequential control
- **PID control – explain !**
- Explain Optimal sensor-based control - LQG
- Satellite control
  - What is detumbling ?
  - Can you explain the  $\dot{B}$  control law ?