Water process

- HW1-2 simulated water process
- HW3 real pilot (DMC/QDMC) or simulated (KF)
  - support on water tank process from Istvan Selek
  - real pilot is available on week 16 (TF319-2)
    - max 3h / day

Process model

- Simulator:
  - Matlab 2022b or newer
  - simulointimalli_1sa.slx (Simulink-model)
  - simulointiparametrit.m (model parameters)
  - simu_1sa.m (sample simulator)
    - function to compute y(k+1)=f(y(k), u(k))
    - select in code whether $y:=h_1$ or $y:=h_2$
    - guide: >> help simu1sa
  - alternatively the controller can be coded using *Matlab-function* block in Simulink (see simulointimalli_PI.slx)

Water process simulation
practical hints

- h = simu_1sa(PumpV, W)
  - where h is the water height at instant k+1
  - PumpV ja W are control u_p and disturbance w at instant k
    - zero order hold
  - sampling time Ts can be set in the code (t = kT_s)
  - the output h can be set in the code (tank 1 or tank 2)
- prior to running simu_1sa,
  - define global variables
    - global H10_ H20_ PumpV_ W_
  - run simulointiparametrit.m
    - simulointiparametrit

- DMC/QDMC is based on a linear model
  - valid around the **linearization point** LP ($\underline{u}_p$,$\underline{h}$)

  - Take this into account while coding, i.e., use deviations around LP:
    - as MPC reference: $r=h_{ref}-\underline{h}$
    - as MPC measurement: $y=h-\underline{h}$
    - as process control input: $u_p=u+\underline{u}_p$
  - both when building the models and when implementing control.
  - Not always necessary (!), but always safer
    - e.g. for error $e=(r-\underline{h})-(y-\underline{h})=r-y$
    - DMC & QDMC compute du=u(k)-u(k-1), i.e. only initial value depends on $\underline{u}_p$
    - a must when building the FIR/FSR models:
      - $y = h-\underline{h}$, $u = u-\underline{u}_p$

Coding hints

```
%% Aloitus
% tyhjennä työtila
clear
% määrittele globaalit muuttujat (tarvitaan Simulink-mallia varten)
global H10_ H20_ PumpV_ W_
% määrittele linearisointipiste
UP_LP = 10; % pumpun jännite tp-tilassa
W_LP = 0; % manuaaliventtiilin asento tp-tilassa (kiinni)
H1_LP = 15.09; % ylemmän (1.) tankin pinta tasapainotilassa kun up=10V ja w=0
H2_LP = 15.09; % alemman (2.) tankin pinta
H10_ = H1_LP % asetetaan linearisointipiste prosessin alkutilaksi
H20_ = H2_LP;
% ajetaan simulointimallin parametrit työtilaan
simulointiparametrit
% määritetään malliksi simu_1sa
plantmodel = @(y,u,d) simu_1sa(u,d)
H_LP = H1_LP;  % säädettävän pinnankorkeuden mukaan
```

- Tee FSR mallinnusaskel linearisointipisteestä
  - H10_ = H1_LP; H20_ = H2_LP; % alusta simulaattorin tila
  - for i=1:n
    - up = UP_LP + stepsize
    - …
- Vähennä linearisointipiste vasteen arvosta =>
    - su(i) = (1/stepsize)*(y(k+1) - H_LP)
  - end
- Anna säätösimuloinnissa ohjauksen alkuarvoksi linearisointipiste:
  - u(1) = UP_LP