MISR UNIVERSITY FOR SCIENCE AND TECHNOLOGY
COLLEGE OF ENGINEERING
MECHATRONICS DEPARTMENT

MTE 506 DIGITAL CONTROL

LAB 5 – SPRING 2019

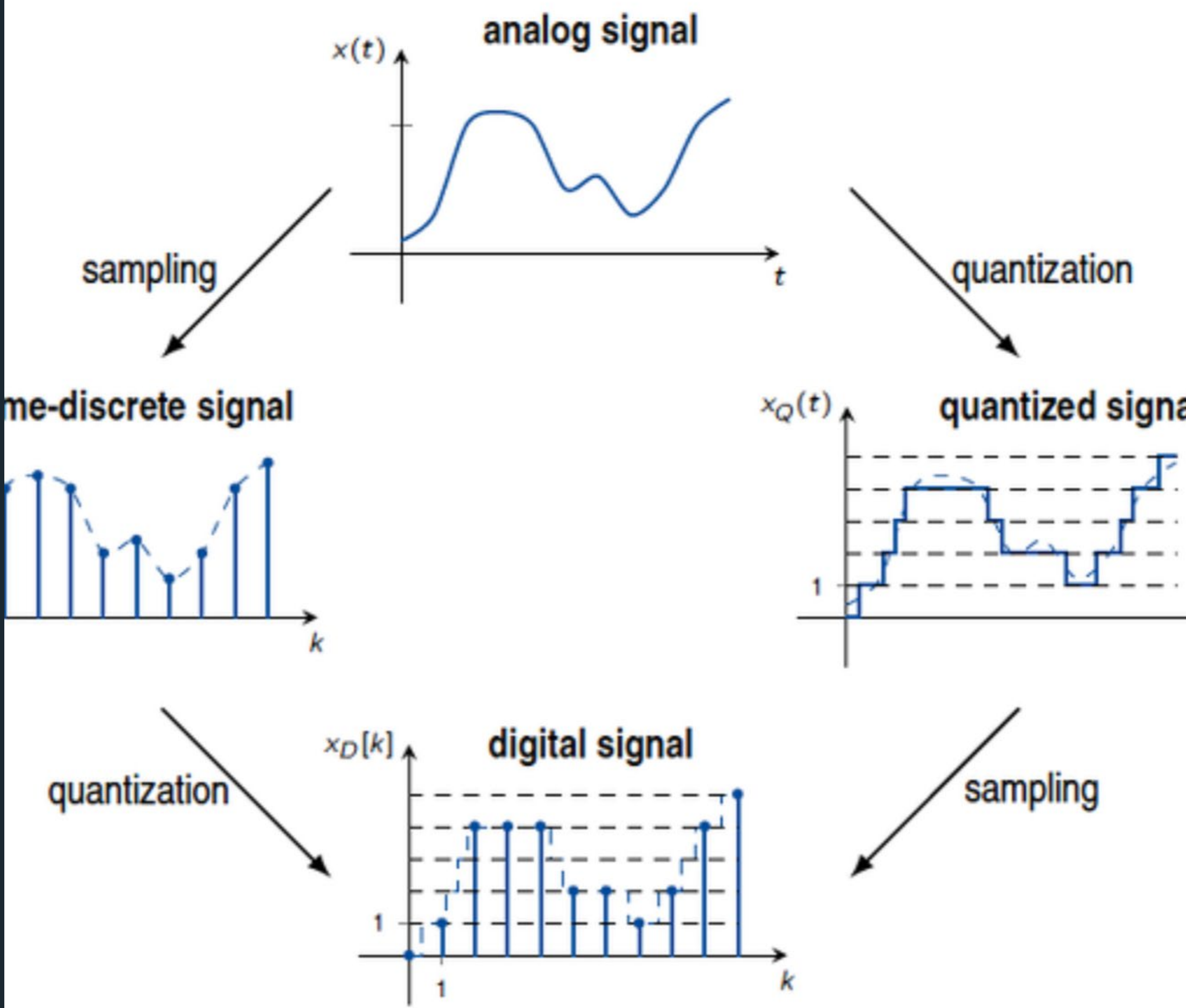
Lab 5

Goals of The Lab

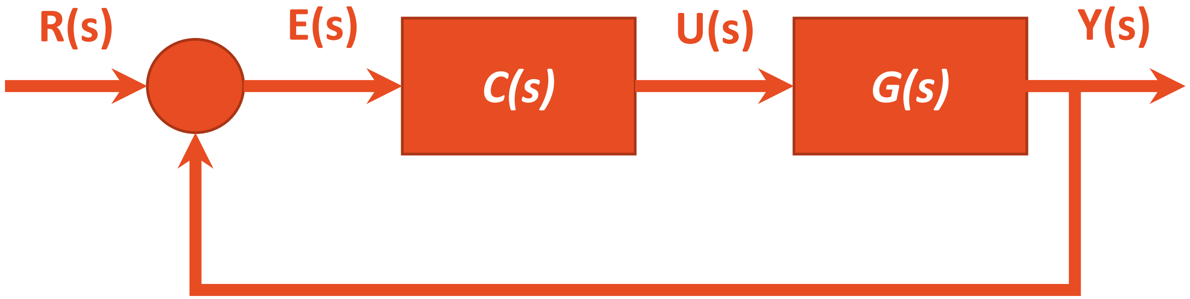
- Discrete Systems Nomenclature
- Practicing on Difference Equation

Lab 5

Continuous vs. Discrete Systems

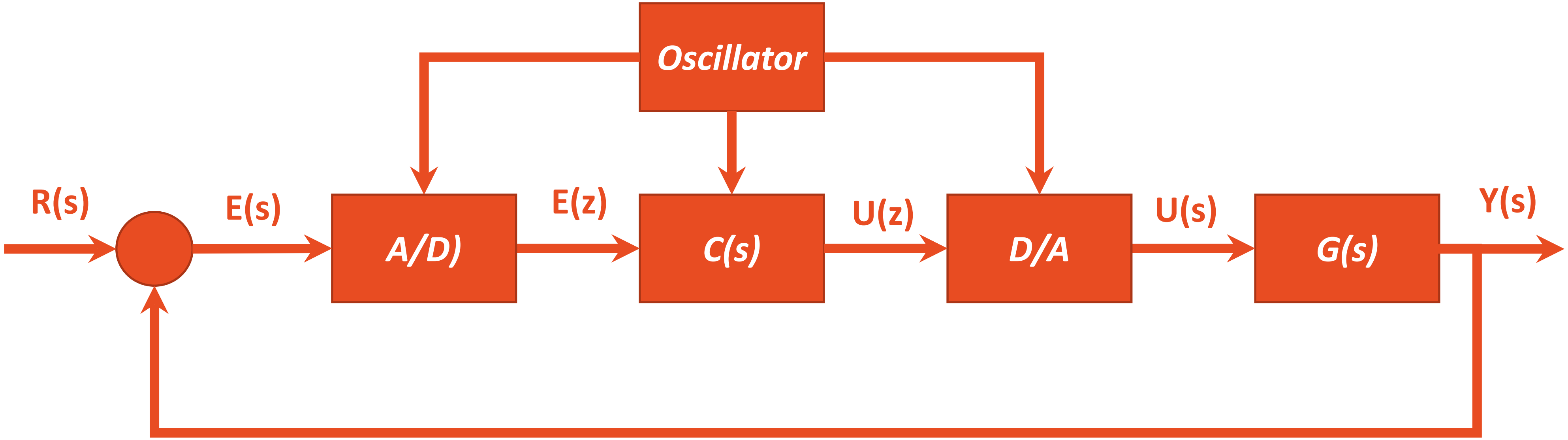


Continuous System vs. Discrete System



$R(s)$ … *Stimulation signal*
$E(s)$ … *Error signal*
$C(s)$ … *Controller*
$U(s)$ … *Control Action*
$Y(s)$ … *Sensor Output*

Continuous System vs. **Discrete System**



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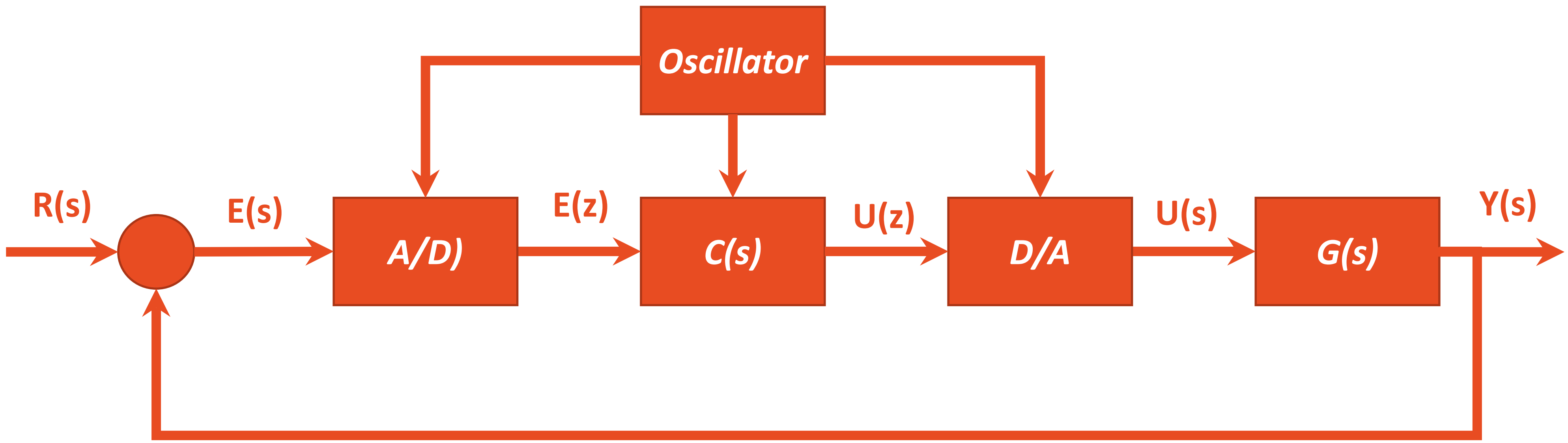
$E(z)$ … *Discretized error signal*
$U(z)$ … *Discretized Control Action*

Continuous System vs. **Discrete System**



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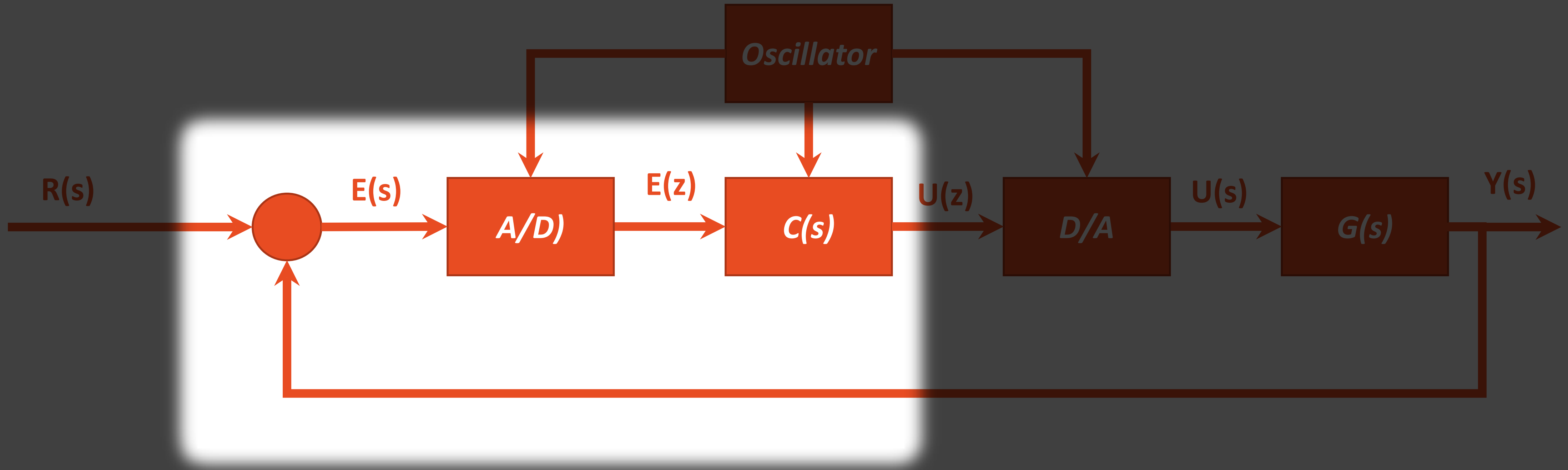


Modern Controllers

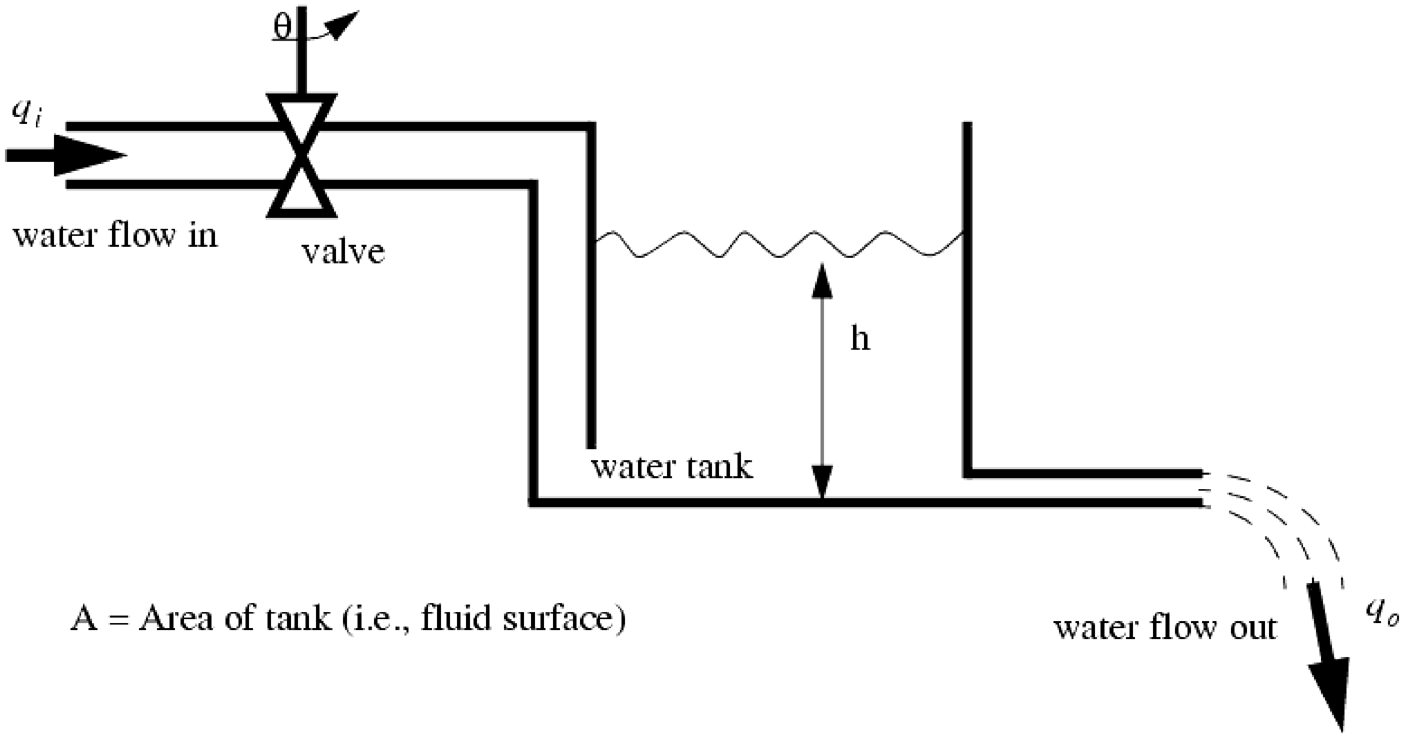
Lab 5

Simulating Water Tank

Revisited

Conversion to Discrete System

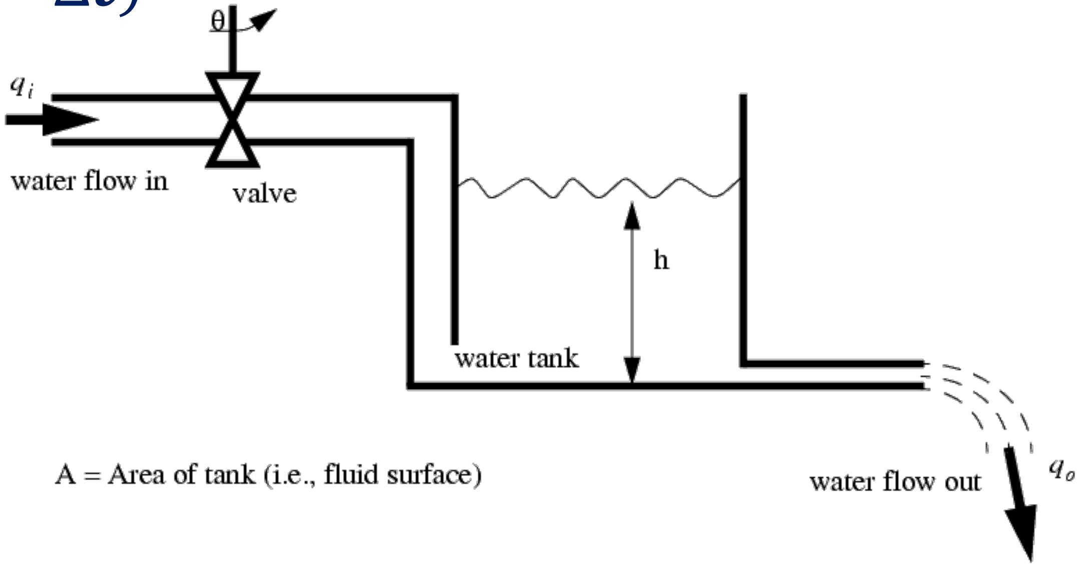
Difference Equation



In Lab 1 ….

$$h(t) = \frac{\Delta t \ * (k * h(t-\Delta t) - \ q_i(t))}{A} + h(t-\Delta t)$$

$\Delta t \ldots Sampling\ time$ $q_i(t) \ldots Excitation signal$



$Let\ \Delta t\ be\ T\ (textbook\ term)$

$Samples$:

$T\ , 2T\ , 3T\ \ldots\ldots kT\ ,\qquad k > 0$

$$h(kT) = \frac{T \ * (k * h(kT-1) - \ q_i(kT))}{A} + h(kT-1)\ [Difference\ Equation]$$

Difference Equation

$$h(kT) = \frac{T \ * (k * h(kT-1) - \ q_i(kT))}{A} + \ h(kT-1)$$

$iF\ T = 1\ second\ (most\ problems\ assuming\ this\ for\ simplicty$

$$h(k) = \frac{(k * h(k-1) - \ q_i(t))}{A} + \ h(k-1)$$

$$A[h(k) \ - h(k-1)] - k * h(k-1) = -\ q_i(t)$$

$$A * h(k) \ - A * h(k-1) - k * h(k-1) = -\ q_i(t)$$

$$A * h(k) \ - [A + k] * h(k-1) = -\ q_i(t)$$

$$\boxed{\begin{gathered}[A + k] * h(k-1) - A * h(k) \ = \ q_i(t) \\ [Difference\ Equation]\end{gathered}}$$

Difference Equation

$$\underbrace{[A+k]*h(k-1)-A*h(k)}_{\text{System Output}} = \underbrace{q_i(t)}_{\text{System Input}}$$

$$if\ k=0 \ \rightarrow h(k-1)=h(0)$$

Difference Equation

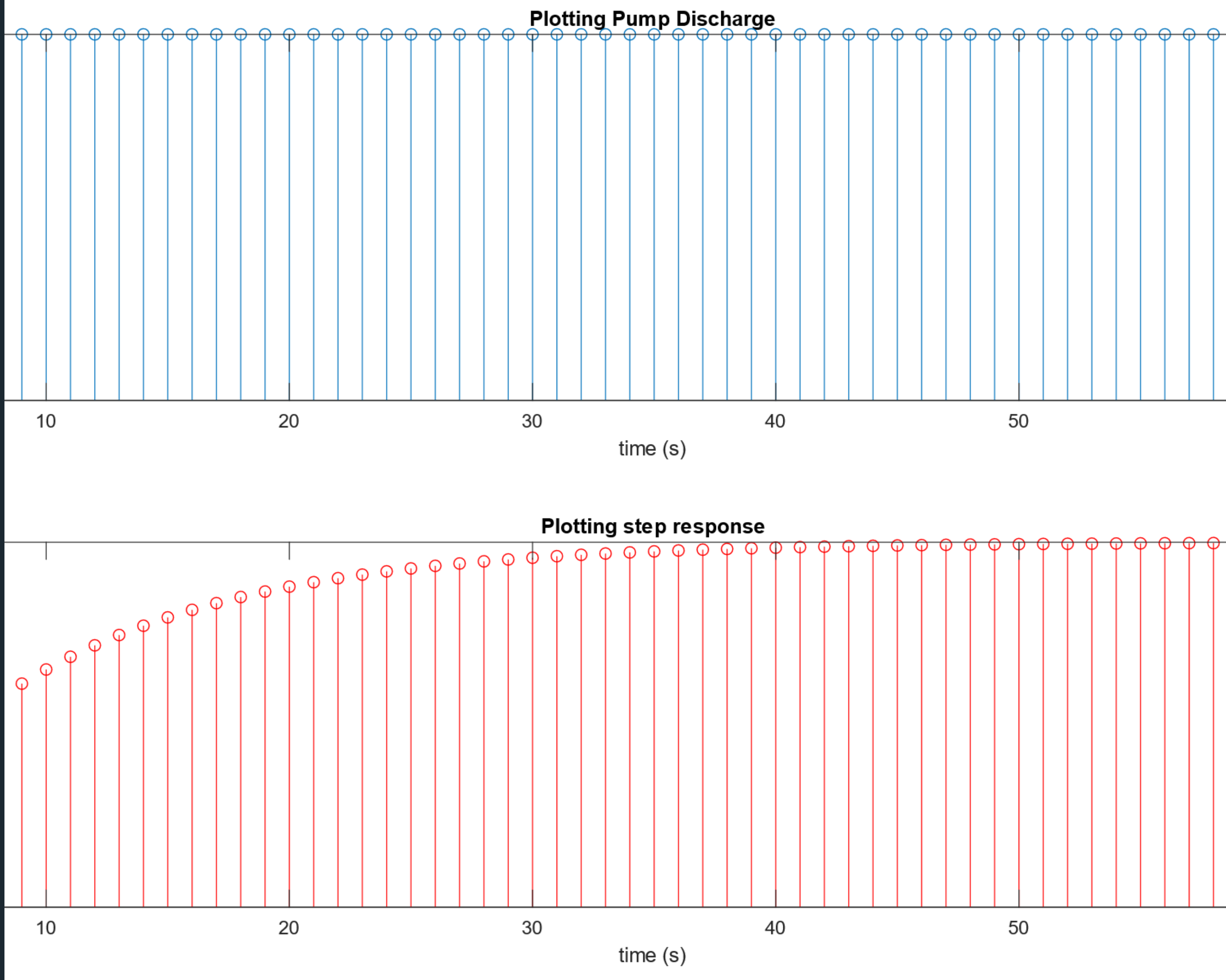
Remember

$$\frac{dh}{dT} = h(t) - h(t - \Delta t) = h(kT) - h(kT - 1)$$

Lab 5

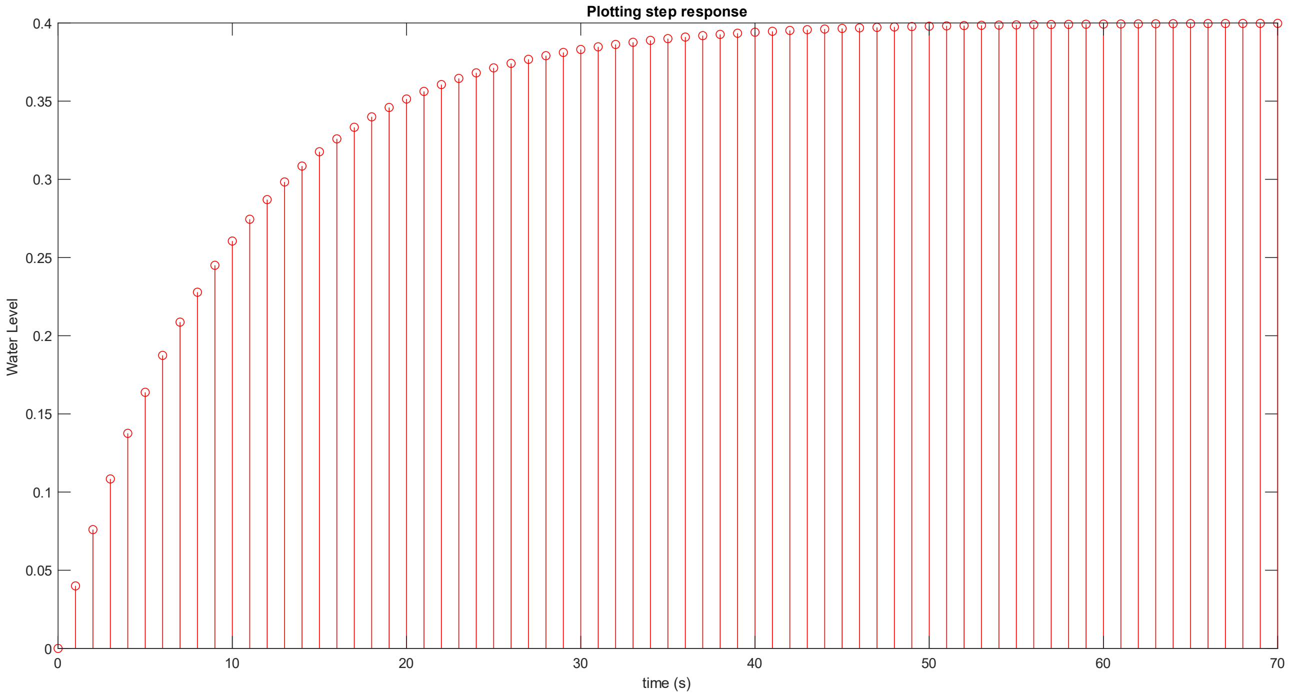
Exercise 1

Representation of discrete response using MATLAB



MATLAB command

$$stem\ (t, y)\ \ldots plots\ discretized\ \ (SAMPLED) data$$



Lab 5

Solved Example

Difference Equation

me system shown in Figure 12.7.
$k = 0, 1, 2, \ldots,$ then the system
. This text studies only the class
s can be described by linear differe
ch as

$$+ 2y(k+1) - y(k) = 2u(k +$$

$$- 1) - y(k-2) = 2u(k-1)$$

Difference Equation Example

$$3y(k+2)+2y(k+1)-y(k)=2u(k+1)-3u(k)$$

Find y value after 3 seconds assuming 1 s sampling interval

Solution

Rearranging equation terms by changing future term to past:

$$y(k+2)\rightarrow y(k)\ (\text{present})\rightarrow \text{replace k with k}-2$$

$$\therefore\ 3y(k)+2y(k-1)-y(k-2)=2u(k-1)-3u(k-2)$$

Difference Equation Example

$$\therefore 3y(k) = 2u(k-1) - 3u(k-2) - 2y(k-1) + y(k-2)$$

$$\therefore y(k) = \frac{1}{3}[2u(k-1) - 3u(k-2) - 2y(k-1) + y(k-2)]$$

Initial conditions needed

$$y(-2) = 1\,, y(-1) = -2 \text{ and } \mathrm{u(k)} = 1 \text{ [unit step]}$$

We need to compute $y(0) \rightarrow y(1) \rightarrow y(2) \rightarrow \mathrm{y}(3)$

Difference Equation Example

$$y(-2) = 1 \,, y(-1) = -2 \text{ and } \mathrm{u(k)} = 1 \text{ [unit step]}$$

$$y(0) = \frac{1}{3}[2u(-1) - 3u(-2) - 2y(-1) + y(-2)]$$

$$= \frac{1}{3}[2 * (0) - 3 * (0) - 2 * (-2) + (1)] = \frac{5}{3}$$

$$y(1) = \frac{1}{3}[2u(0) - 3u(-1) - 2y(0) + y(-1)]$$

$$= \frac{1}{3}\left[2 * (1) - 3 * (0) - 2 * (\frac{5}{3}) + (-2)\right] = -\frac{10}{9}$$

Difference Equation Example

$$y(-2) = 1\,, y(-1) = -2 \text{ and } \mathrm{u(k)} = 1 \text{ [unit step]}$$

$$y(2) = \frac{1}{3}[2u(1) - 3u(0) - 2y(1) + y(0)]$$

$$= \frac{1}{3}\left[2 * (1) - 3 * (1) - 2 * (-\frac{10}{9}) + (\frac{5}{3})\right] = \frac{26}{27}$$

$$y(3) = \frac{1}{3}[2u(2) - 3u(1) - 2y(2) + y(1)]$$

$$= \frac{1}{3}\left[2 * (1) - 3 * (1) - 2 * (\frac{26}{27}) + (-\frac{10}{9})\right] = -\frac{109}{27}$$

Asignment

$$3y(k+2)+2y(k+1)-y(k)=2u(k+1)-3u(k)$$

Write a MATLAB script to calculate $y(k)$ *given* $k, y(-1), y(-2)$ *assuming unit step input*

Due date (today 11:59 PM)

Send to : waleed.elbadry@must.edu.eg

Don’t forget to pull the lab update from.

http://github.com/wbadry/mte506

Waleed El-Badry

END OF Lab 5