ELEC-E8101 Digital and Optimal Control
Intermediate exam 1 19. 10. 2022

- *Write the name of the course, your name and student number to each answer sheet.*
- *There are three (3) problems and each one must be answered.*
- *No other literature except the Table of Formulas is allowed. A calculator can be used. Only basic calculations with it are allowed (e.g. no matrix calculations, Laplace- or Z-transformations, www-connections).*
- *The table of formulas must be returned, if you have received it from the exam supervisor.*

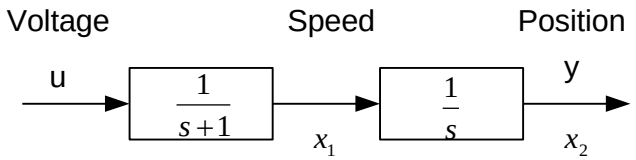
Three (3) problems, max. 6 points each.

In solving the problems you can use the Tables as much as you wish. Note above the conditions for using the pocket calculator; it is only an aid for basic calculations**. Write your solutions in a way, where it becomes perfectly clear how you have obtained the solution.**

1. You are working in a company called *Full-service automation house*, which does automation projects for the industry. Your client asks for a short written explanation to the following concepts, which appear in your documents. Write those short descriptions. Please note that the client is somewhat aware of continuous time control theory and automation but does not know digital control. Also, the client does not want to read long explanations.

- zero-order hold	(1 p.)
- pulse transfer function	(1 p.)
- alias effect	(1 p.)
- hidden oscillations	(1 p.)
- BIBO stability	(1 p.)
- final value theorem and its use in the determination of static gain (discrete time case)	(1p.)

2. A DC/DC motor can be described by the simple model below, where u is the voltage input and y the shaft position.



a. Determine the transfer function and state-space representation of the continuous time system. Use the state variables shown in the figure. (1 p.)

b. Determine the corresponding discrete-time pulse transfer function when zero order hold is assumed and the sampling interval is h. (3 p.)

c. Explain verbally the correspondence $z = e^{sh}$. Verify that it holds in this case. (2 p.)

3. Consider the model

$$\begin{cases} x(kh+h) = \begin{bmatrix} 1 & h \\ 0 & 1 \end{bmatrix} x(kh) + \begin{bmatrix} \frac{1}{2}h^2 \\ h \end{bmatrix} u(kh) \\ y(kh) = \begin{bmatrix} 1 & 0 \end{bmatrix} x(kh) \end{cases}$$

where h is the sampling interval.

a. Determine the pulse transfer function. Based on that, deduce what kind of process the model describes? What is the corresponding continuous-time transfer function, under the assumption of ZOH? (2 p.)

b. Is the system i. reachable, ii. observable? Explain in words what your answers mean. (2 p.)

c. Is the process asymptotically stable? Is it BIBO stable? (2 p.)