N TEST EXAM FOUR

Introduction & Instructions

This is the resit exam of BCS 2024 MAY.

- Duration: **3 hours**
- Number of problems: **9**
- Allowed material: **Writing gear, calculator**
- Calculation of final scores: $\frac{\text{score\_obtained}}{10}$, round to 1 decimal
- Note for grading: correct solutions without reasoning do **not** grant points.

Question 1 (10 pionts)

Give the overall transfer function $H(s) = \frac{Y(s)}{R(s)}$ of this block diagram in Fig. N.1.
Show at least two intermediate steps used to find the solution.

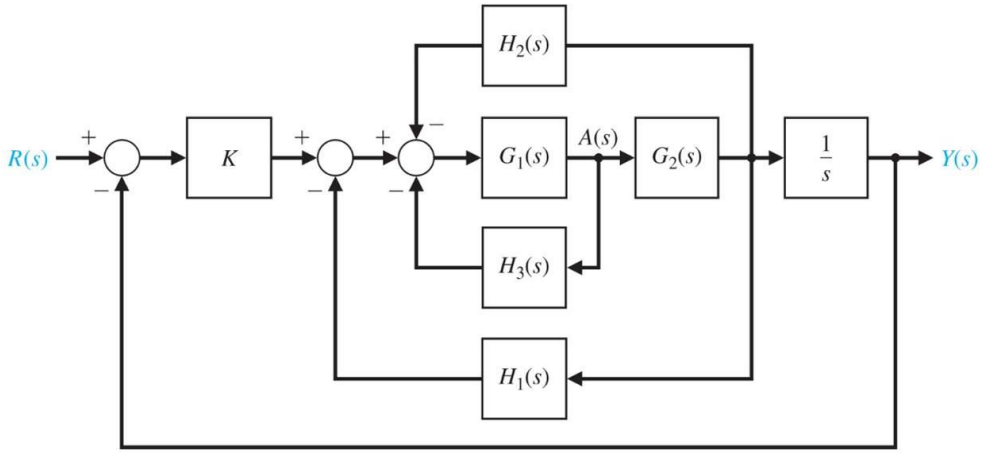

Figure N.1: Block diagram.

Question 2 (10 pionts)

1. Determine $H(s) = \frac{Y(s)}{X(s)}$ for the following differential equation.

$$3y''' + 6y'' + 15y' = x' + 4x$$

   (assume that all initial conditions are zero)

2. Draw the poles, zeros in the complex plane. Also mention the gain K.
3. What is the DC gain of $H(s)$? Explain the answer you get.

Question 3 (15 pionts)

Determine the transfer function $H_P(s)$ and its parameters K_P, τ_P and τ_v from the following step response graph in Fig. N.2.

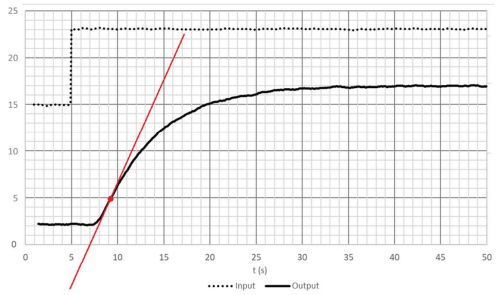

Figure N.2: The step response data

Assume the process to be a **delayed first order process**. The point of inflection and tangent are already drawn. Use the graph in the answer sheet to show how you find the parameters.

Sketch sheet problem 3

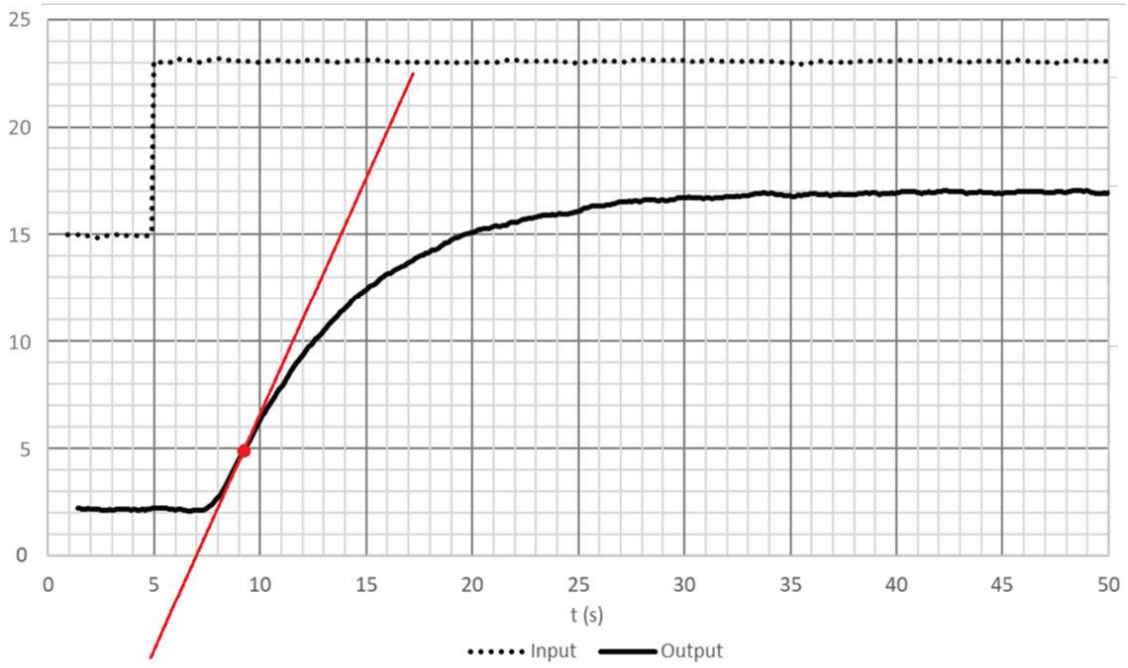

Figure N.3: The step response data

Question 4 (15 pionts)

Sketch the magnitude and phase part of the Bode diagram of $H(s)$:

$$H(s) = \frac{30s(s+15)}{(s+5)^2}$$

Explain how you obtained your sketch.

Question 5 (10 pionts)

1. Find the function $h(t)$ of the following transfer function $H(s)$:

$$H(s) = \frac{2s+4}{s^2+2s+7}$$

2. If $G(s)$ is the transfer function of a system. Will there be overshoot for a step input? And if there is overshoot, how much will that overshoot be?

$$G(s) = \frac{1}{s^2+2s+3}$$

Question 6 (15 pionts)

Given the following Bode diagram in Fig. N.4 of an (open loop) process with transfer function $G(s)$.

1. What is the gain margin as shown in this Bode diagram?
2. Assume $G(s)$ is placed in a negative feedback loop with unity feedback. What can be the gain. What can be the gain K (with $K > 0$) of the controller such that the phase marjin of the system is 45°?

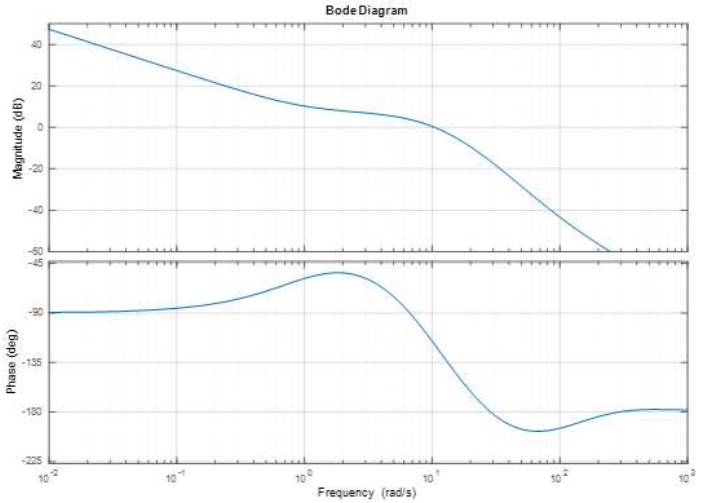

Figure N.4: Bode diagram

Question 7 (10 pionts)

The following Nyquist diagram in Fig. N.5 is obtained from the process $G(s)$ with a P-controller $K = 1$.

$$G(s) = \frac{-s^4 - 6s^2 - s - 1}{0.6s^4 + 21s^3 - 15s^2 - 2.51s - 2}$$

The four open-loop poles of $G(s)$ are located at:

$$35.7036 + 0.000\mathbf{i} \quad -0.7179 + 0.000\mathbf{i} \quad 0.0072 + 0.3606\mathbf{i} \quad 0.0072 - 0.3606\mathbf{i}$$

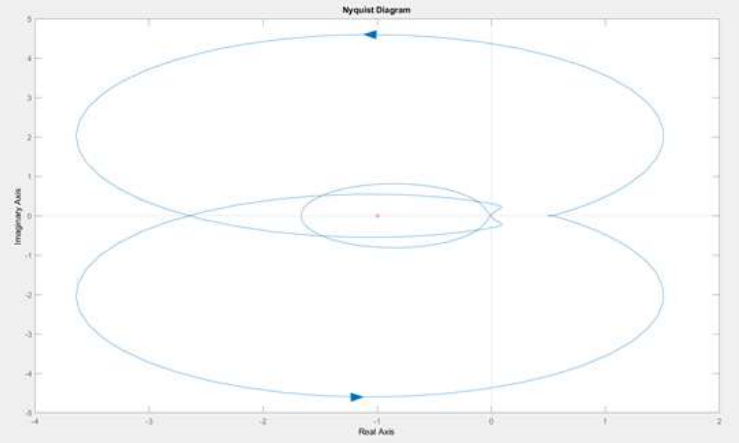

Figure N.5: Nyquist diagram

Question 8 (10 pionts)

What is the Laplace transform of the following function $f(t)$ as shown in Fig. N.6.
Explain how you obtained your answer (show intermediate steps).

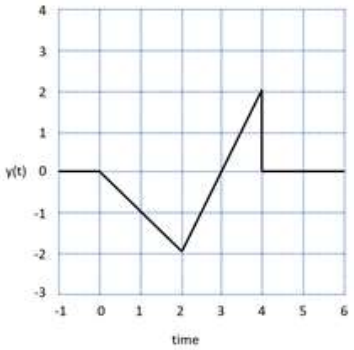

Figure N.6: $f(t)$

Question 9 (5 pionts)

A PID-controller has three distinct functions, the P-, I- and D-action.
Describe the purpose of each function.