LAST NAME	
FIRST NAME	
MATRIKEL-NO.	

Problem 1

(2 points each)

a) Name and draw three typical input signals used in control technique.

b) What is a weight function?

c) Define the eigen value of a system as well as the pole of a transfer function. Show in the case of a one-variable system without so called pole/node reduction possible correlations.

d) Give the input/output behavior of a PDT_2-system as a differential equation as well as a transfer function.

e) Define mathematically:

- the complete state space description of a linear MIMO-system,
- the corresponding transfer function of a system with the matrices and vectors of the state space description, and
- the algorithm for the corresponding eigen values and eigen vectors.

Problem 2

(2 points each)

a) A transfer system shows a PIT_3-transfering behavior. Give the transfer function and draw the step response of the system.

b) How can the damping of a stable eigen-value be calculated from its numerical value? Within which range of values for the damping constant does oscillations occur?

c) What information is given in the Fourier-spectrum?

d) Give the general algorithm of the Laplace transformation for a function $f(t)$. Calculate the Laplace transformation of the Dirac function by hand.

e) A transfer system with a PIT_1-behavior is controlled with a transfer system with PI-behavior. Draw the block diagram and give the equation for the disturbance and the reference transfer function.

Problem 3

(15 Points)
Below is a block diagram of an electric motor given. The reference signal is the input voltage V and the output is the angular velocity ω. The model consists of two transfer functions, one for the electrical part $G_1(s) = \frac{K_t}{Ls+R}$ and one for the mechanical part $G_2(s) = \frac{1}{Js+b}$. The constant K_e is the voltage constant.

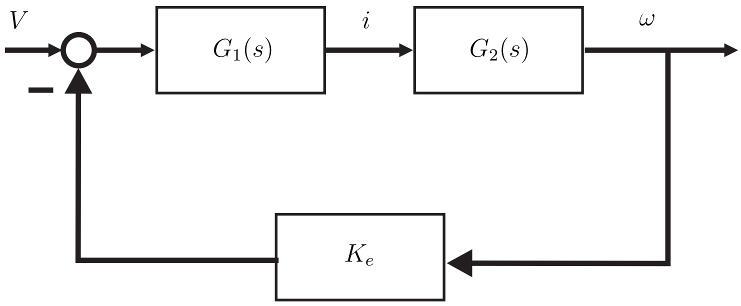

Figure 3.1: Block diagram of an electrical DC-motor

a) Calculate the transfer function, $G_{V\omega}(s) = \frac{\omega}{V}$.

b) Assume: $K_t = 1$, $L = 1$, $R = 3$, $J = 1$, and $b = 2$. For which K_e will the system oscillate?

c) A PI-controller, with constants $T_I = 1$ and $K_I = 1$, is inserted to realize torque control with the help of feeding back the current i, see Figure 3.2. Calculate the transfer function for the closed system $G_c(s) = \frac{\omega}{r}$. Assume the same constant values as in b) and assume $K_e = 1$.

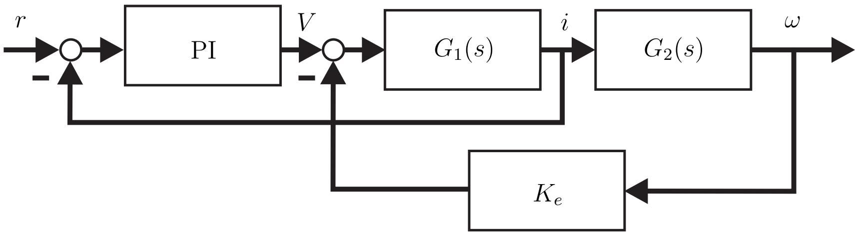

Figure 3.2: Block diagram of the electric motor with torque control

d) Determine the output initial- and final values of the system in c) for a step input. Determine then the corresponding output gradients (derivatives) for a step input. Based on these results, plot the step response qualitatively.

Problem 4

(15 points)

For the illustrated hydraulic cylinder in Figure 4.1 the equation of motion for the one-way motion is given by: $\dot{y} = \frac{q}{A}$.

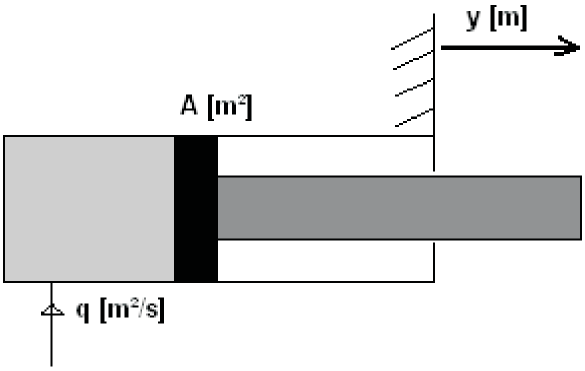

Figure 4.1: Sketch of hydraulic cylinder

a) State the transfer function $G(s) = \frac{Y(s)}{Q(s)}$.

b) A (positive and negative feedback) closed-loop control should be realized for the given system using:

   1. PIT_1- element as controller with $T_1 = 1$, $T_\mathrm{I} = 1$, and
   2. PDT_1- element as controller with $T_1 = 1$, $T_\mathrm{D} = 2$.

   Draw the root locus plot of the (negative and positive feedback) systems for the two given controllers. Can the system behavior be stabilized asymptotically?

   A new system is defined by the transfer function as following:

$$G(s) = \frac{1}{(s^2 + 5s + 6)(s + 1)}.$$

c) A P-controller (K_p) is used to control this system. Check the stability of the closed-loop system.

d) Plot the Bode diagram of the open-loop system using parameter $K_p = 6$.

Problem 5

(16 Points)

A transfer behavior of a system was measured and is displayed in Figure 5.1.

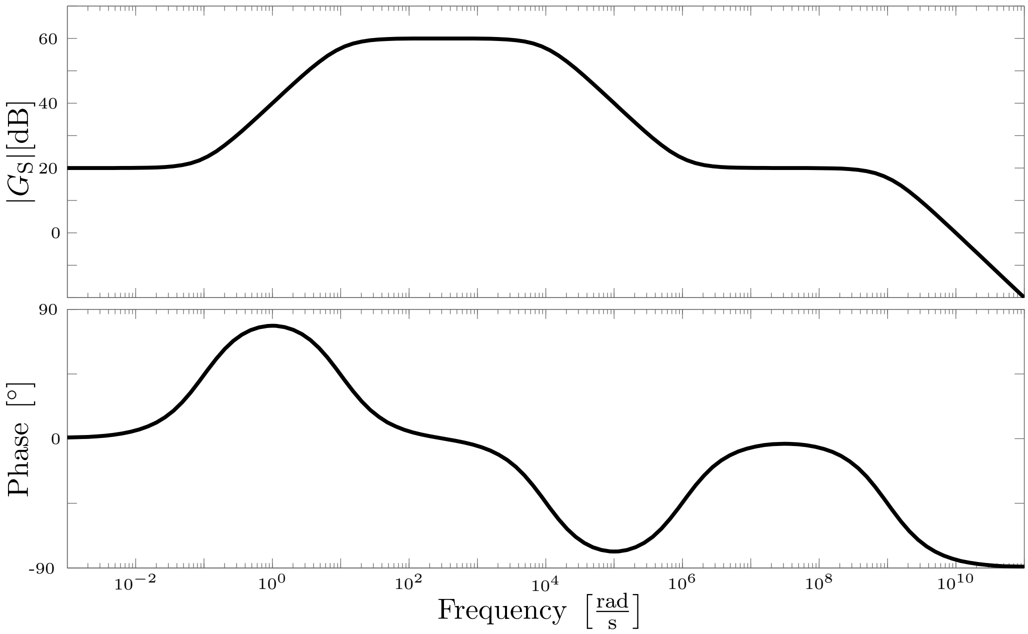

Figure 5.1: Bode plot of a system

a) Draw in the asymptotes for the amplitude and phase behavior in Figure 5.1.

b) State the transfer function $G_S(s)$ for the given system (Figure 5.1) by using the break-point frequencies ω_i (qualitatively). State also the gain K_S.

c) The transfer characteristic of the system is optimized by applying a filter $G_F(s)$. The new desired transfer behavior $G_o(s) = G_S(s)G_F(s)$ is shown in Figure 5.2 (system and filter). State the transfer function $G_F(s)$ and the desired gain K_F of the new filter.

d) Draw in the asymptotes for the amplitude and phase behavior of $G_F(s)$ in Figure 5.3.

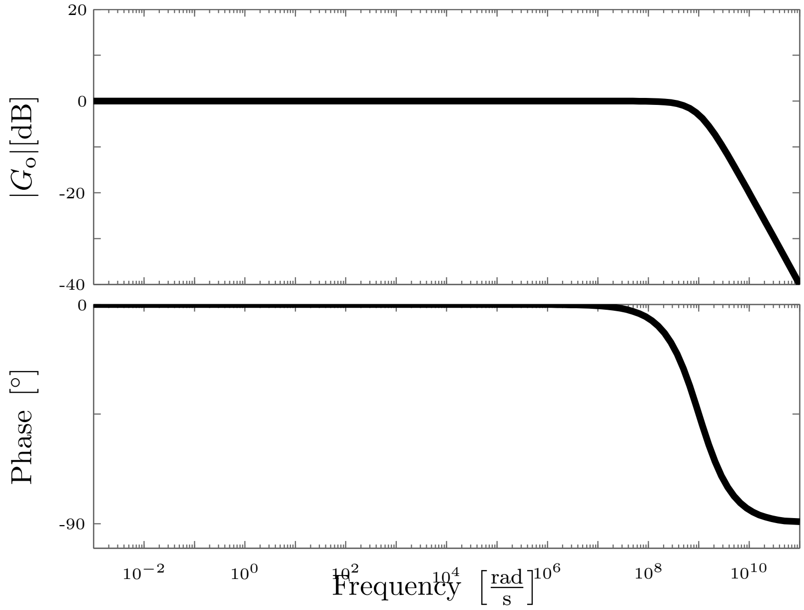

Figure 5.2: Bode plot of the desired system

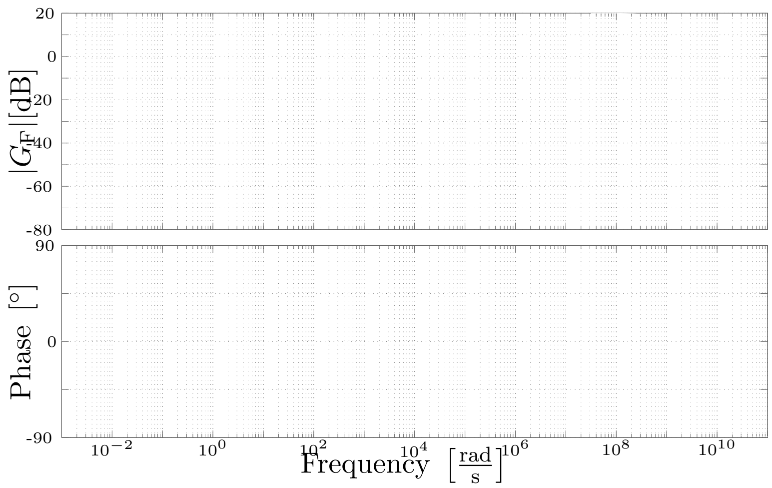

Figure 5.3: Bode plot of the filter (asymptotes)

Maximum achievable points:	**66**
Minimum percentage of points for the grade 1,0:	**95%**
Minimum percentage of points for the grade 4,0:	**50%**