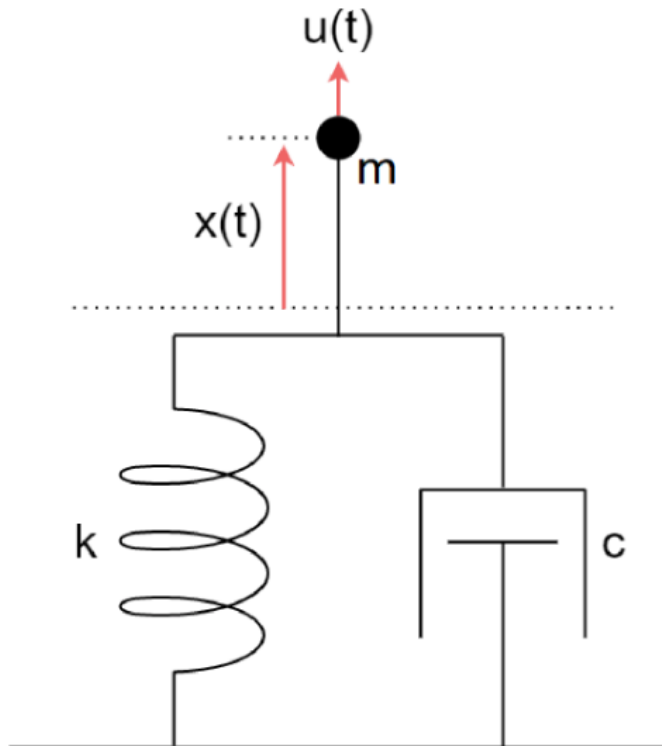


Control theory part 2

Note: Some of the sub-tasks were already a part of last week's "ukeoppgaver" but could be relevant for this week's tasks. This week's sub-tasks are enclosed in a rectangle.

Exam task 5 – 2022

5.1 Mass-spring-damper system



Figuren over viser et dempet masse-fjær-system, der m er objektets masse, k er fjærkonstanten, c er dempings koeffisienten, D er eksterne krefter klassifisert som støy, $x(t)$ er massens forlytning ved tid t , and $u(t)$ er kontrollkraften ved tid t .

Systemet kan beskrives ved følgende andre-ordens differensiallikning:

$$m\ddot{x}(t) + c\dot{x}(t) + kx(t) + D = u(t)$$

Oppgaver:

Transformer likningen over fra tidsdomenet til Laplacedomenet. Tegn et lukket-sløyfe blokkdiagram for systemet.

Maks poeng: 5

5.2 PI-controller

Legg til en PI-kontroller til systemet, med en ønsket masseforflytning $X_d(s)$. Inkluder PI-kontrolleren i systemets likning (likningen fra oppgave 5.1). Finn transferfunksjonen ved å løse den nye likningen med hensyn på $X(s)$.

Maks poeng: 5

5.3 Steady state error

Anta at systemet får steginput $X_d(s) = \frac{\omega}{s}$ og konstant forstyrrelse $\frac{d}{s}$. Bruk sluttverditeoremet gitt under til å finne feilen når systemet har stabilisert seg (steady-state error).

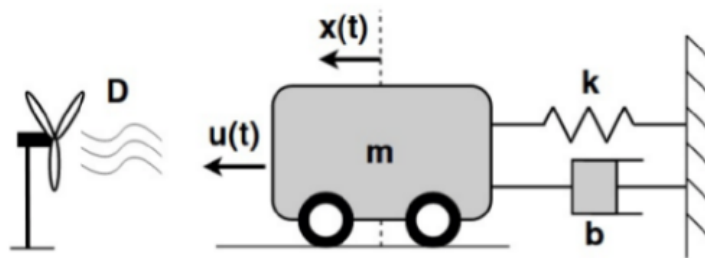
$$\lim_{t \rightarrow \infty} f(t) = \lim_{s \rightarrow 0} sX(s)$$

Hvordan vil feilen påvirkes om vi fjerner integralkomponenten fra kontrolleren?

Maks poeng: 5

Exam task 7 - 2019

Task 7: Mass-spring-damper Control (16%)



The above image demonstrates a mass-spring-damper system, where m is the object mass, k is the spring constant, b is the damping coefficient, D is the system disturbance, $x(t)$ is the mass displacement at time t , and $u(t)$ is the input force. The system can be described with the following differential equation:

$$m\ddot{x}(t) + b\dot{x}(t) + kx(t) + D(t) = u(t)$$

a) 5% Transform the above equation from time domain to Laplace domain. Draw the closed-loop block diagram of the system.

b) 6% Suppose that a PD compensator is added to the system, and $X_d(s)$ is the desired mass displacement. Transform the system equation in Laplace domain (that you obtained in (a)) so that it includes the PD compensator. Solve the resulting equation for $X(s)$.

c) 5% Assume that the system receives a step reference input $X_d(s) = \frac{\psi}{s}$ and constant disturbance $\frac{d}{s}$. Use the final value theorem below to determine the steady-state error:

$$\lim_{t \rightarrow \infty} x(t) = \lim_{s \rightarrow 0} sX(s)$$

If you needed to eliminate the steady-state error and could use a different compensator to do so, which compensator would you choose?

Exam task – 2018

Task 4 [INF3480/INF4380] (20%):

We have the system $J\ddot{\theta}(t) + B\dot{\theta}(t) + K\theta(t) = \tau$. When we use the Laplace transform on the system, we get $J s^2 \theta(s) + B s \theta(s) + K \theta(s) = \tau$.

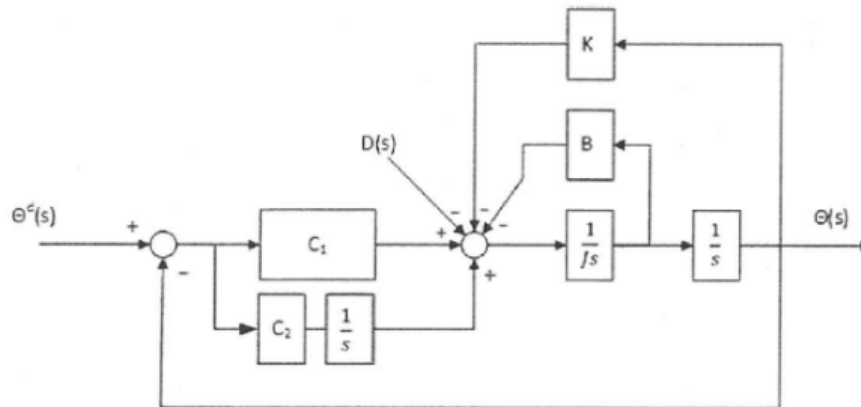


Figure 4: Control system

a) (2.5%) Figure 4 shows up a set-point tracking control system in the Laplace domain. What is the name of the controller used here? What properties does it provide to the system?

b) (2.5%) The system with the controller in Figure 4 have oscillations. How can we remove the oscillations while keeping the other system properties? What is the name of the new controller?

c) (5%) Find the closed-loop transfer function between the input value ($\theta_d(s)$ - desired angle) and output value ($\theta(s)$ - actual/measured angle) for the system with this new improved controller.

d) (5%) Use the final value theorem to calculate the steady state error for the closed-loop control system with the new improved controller. Consider both the desired angle $\theta_d(s)$ and the disturbance $D(s)$ to be "step inputs". Comment on the result.

e) (5%) Transform the following equation the Laplace domain:

$$m\ddot{x} + kx = u$$

Find the transfer function of this system, assuming that u is the input and x is the output. Draw a block diagram of the system.

f) (2.5%) How would you examine the stability of the control system, and what is required to get a stable system? Find the poles and zeros of the system in Task 4e when the spring constant is $k = 8$ and the mass of the system is $m = 2$. Show the poles and zeros in a plot. What do we call a system like this?