This course has already ended.

« 4.1 Materials | Course materials | 4.3 Exercises round 4 »

MEC-E5001 / 4. Control / 4.2 Lecture Quiz 4

Lecture Quiz 4

Points **0 / 350** My submissions **0 / 2**
Deadline Tuesday, 6 February 2024, 09:00
To be submitted alone
Show model answer

The deadline for the assignment has passed (Tuesday, 13 February 2024, 09:00).

Why does closed-loop control reduces control errors? Prove it by deriving the closed-loop transfer function and analysing the relation between the output y and reference u. See Figure 1 below for the notation in questions 1-8.

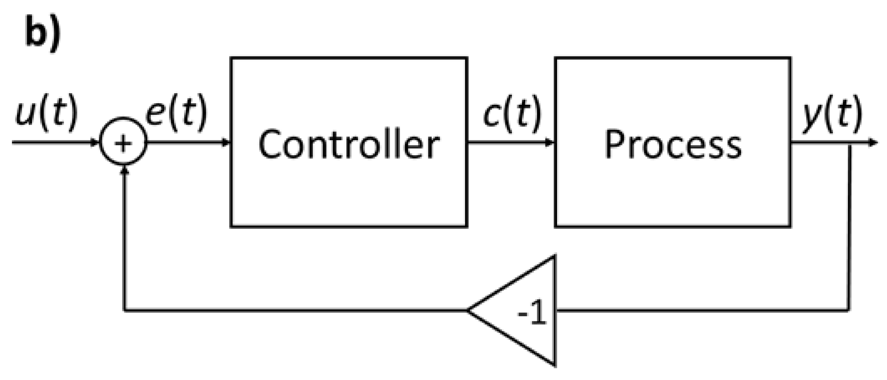

Figure 1. Closed-loop system

Question 1 **29 points**
The **open**-loop transfer function equals to $C(s)$ for Controller and $P(s)$ for Process. Note you need to **cut** feedback loop for open-loop analysis.

- ○ $U(s) - E(s) = C(s)Y(s)$
- ○ $y(t) * u(t) = 0$
- ○ $\frac{Y(s)}{U(s)} = C(s)P(s)$

Question 2 **29 points**
The **closed**-loop transfer function equals to

- ○ $\frac{Y(s)}{U(s)} = \frac{C(s)P(s)}{C(s)P(s)}$
- ○ $\frac{Y(s)}{U(s)} = \frac{C(s)P(s)}{1+C(s)P(s)}$
- ○ $\frac{Y(s)}{U(s)} = \frac{C(s)P(s)}{1-C(s)P(s)}$

Question 3 **29 points**
If the controller C is a large number, the relative tracking error y/u becomes... Note: Assume that the system remains stable even when the controller gain is large

- ○ ...extra large
- ○ ...large
- ○ ...small

Question 4 **29 points**
On the other hand, if the controller C is a small number, the tracking error becomes...

- ○ ...very small
- ○ ...large
- ○ ...small

Design a proportional speed controller for a wheel with inertia J. For a unit step in speed command, 63 % of the command value needs to be achieved in 1 second. Derive the proportional gain K (=controller). The plant (=process) equals to:

$T = J\dot{\omega}$

The system looks like in Figure 1 above.

Question 5 **29 points**
What the system is in Laplace domain as transfer function (open loop control)? (Calculate the transfer function from torque to angular speed.)

- ○ $\frac{\omega(s)}{T(s)} = Js$
- ○ $\frac{\omega(s)}{T(s)} = \frac{1}{Js^2}$
- ○ $\frac{\omega(s)}{T(s)} = \frac{1}{Js}$

Question 6 **29 points**
The closed loop system equals to

- ○ $\frac{y(s)}{u(s)} = \frac{K/J}{s+K/J}$
- ○ $\frac{y(s)}{u(s)} = \frac{K}{K/J}$
- ○ $\frac{y(s)}{u(s)} = \frac{1}{s+KJ}$

Question 7 **29 points**
The rise time of the system is...

- ○ 1 second
- ○ 0.1 second
- ○ 10 seconds

Question 8 **29 points**
What is the proportional gain K of the system? It is based on the time constant.

- ○ $K = 1$
- ○ $K = J$
- ○ $K = Js$

If you would code a PID controller, then what do you need to define and how? Please answer in the tasks below.

Question 9 **29 points**
The code for digital PID controller needs to have the following information

- ○ Corresponding P, I, and D gains, sample time, and signal values for one time step
- ○ Corresponding P, I, and D gains, sample time, and signal values for two successive time steps
- ○ Corresponding P, I, and D gains, sample time, and signal values for three successive time steps

Question 10 **29 points**
The derivative term can be expressed as...

Notation:
K_d: derivative gain
Δt: sample time
$u(t)$: signal to be derived at time instant t

- ○ $K_d(u(t) - u(t-\Delta t)) * \Delta t$
- ○ $K_d u(t)$
- ○ $K_d \frac{u(t)-u(t-\Delta t)}{\Delta t}$

Question 11 **30 points**
The integral term can be expressed...

Notation:
K_I: integral gain
Δt: sample time
$u(t)$: signal to be integrated at time instant t

Assume previous integral value is added later on the integral term you select

- ○ $K_I \frac{u(t)+u(t-\Delta t)}{2} \Delta t$
- ○ $K_I(u(t) - u(t-\Delta t))$
- ○ $K_I u(t)$

Question 12 **30 points**
The proportional term can be expressed

Notation:
K_p: proportional gain
Δt: sample time
$u(t)$: signal at time instant t

- ○ $K_p K_I K_d u(t)$
- ○ $K_p u(t)$
- ○ $K_I u(t)$

Submit