Computation Exercise

- **Successful completion of the computational exercises is a prerequisite for the admission to the final exam.**
- To pass the computation exercises, **a positive result is required for all the following exercises**.
  - Computation exercise 1: Dynamics
  - Computation exercise 2: Actuator
  - Computation exercise 3: Control design

Computation Exercise 3

- For computation exercise 3, two assignments are available:
  - Computation exercise 3(a): System with Lorentz actuator
  - Computation exercise 3(b): System with piezo actuator
- One of the two assignments has to be selected, and its answer must be submitted by the deadline.
- Submission of the exercise
  - Deadline: 20^{th} of January at 4PM (No grace period).
  - Answers must be hard copy with a student name and number.
  - Answers must be submitted to the mail box for Shingo Ito in CA0421.
  - Strongly recommended to work alone. (Don't copy)

Computation Exercise 3

- It is expected that a software (e.g. MATLAB) is used for the computation exercises.
  - Student licenses are available with a reasonable price at “Zentraler Informatikdienst”.
  - Computers with MATLAB and Maple may be available at the computer laboratory (CA0426). Please talk to Shingo Ito after the lecture for reservation.

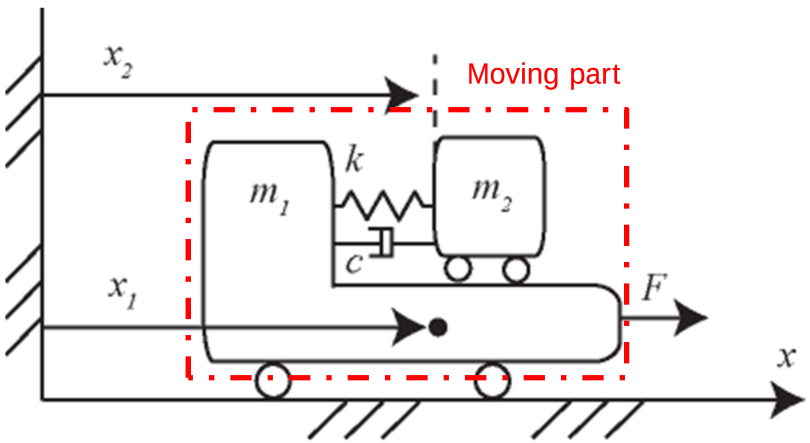
Computation Exercise 3(a)

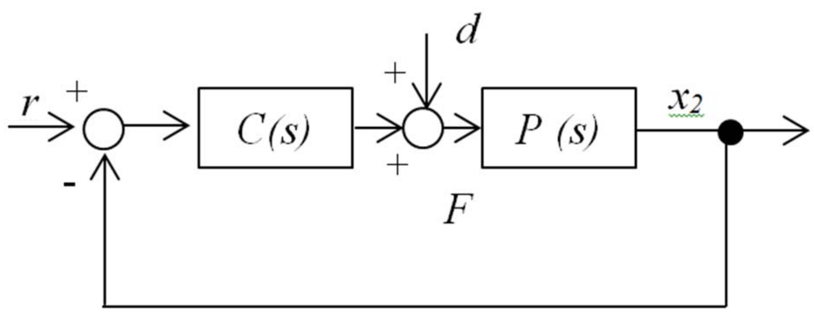
To regulate the position x_2 by using the input *F*, design a feedback controller *C(s)*, following the questions below.

$$C(s) = C_{PID}(s)C_{notch}(s),$$

i. Derive transfer function P(s) and simulate a Bode plot. [5%]

ii. Design the notch filter, such that the peak in the magnitude of *P(s)* is trimmed in the Bode plot of (i). For validation, add a simulated Bode plot of the transfer function $C_{notch}(s)P(s)$ on the figure of (i). [15%]





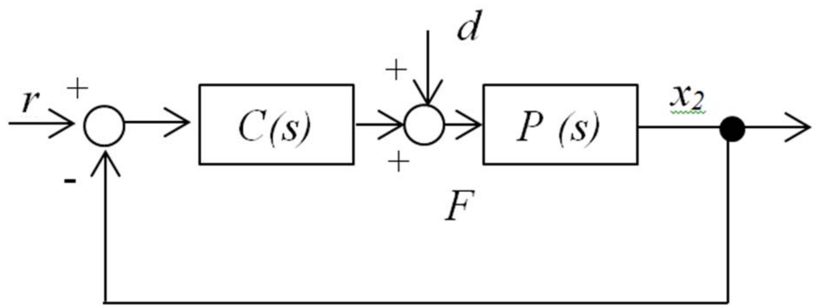
Computation Exercise 3(a)

iii. Design $C_{PID}(s)$ to regulate the plant cascaded with the notch filter (i.e. $C_{notch}(s)P(s)$), fulfilling the following conditions. (See "rule of thumb" in the textbook.) Also simulate a Bode plot of the open-loop transfer function $C_{PID}(s)C_{notch}(s)P(s)$ for validation. [20%]

- Phase margin should be 40 deg or more.
- Gain margin should be 10 dB or more.
- The open-loop cross-over frequency should be as high as possible.

Computation Exercise 3(a)

iv. Simulate step response of the closed-loop system with *r* as the input and x_2 as the output. Also draw step response with the disturbance *d* as the input and x_2 as the output. Using the results, discuss the influence of the notch filter on these inputs. [20%]



There are two more continuous questions. However because they are control implementation problems, they will be explained on January 8th, 2015.

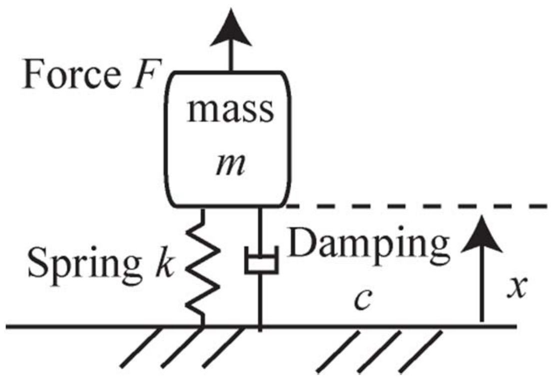
Computation Exercise 3(b)

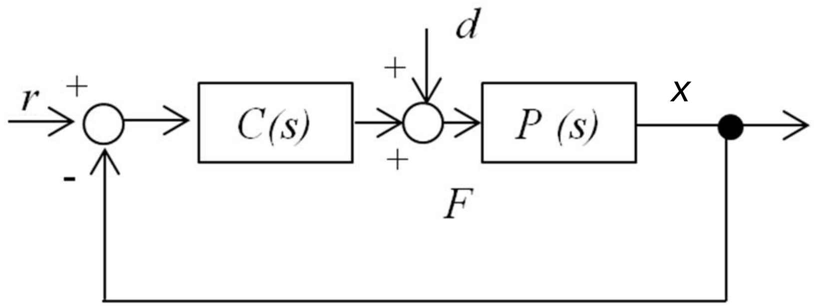
To regulate the position *x* by using the input *F*, design a feedback controller *C(s)*, following the questions below.

$$C(s) = C_I(s)C_{notch}(s),$$

i. Derive transfer function P(s) and simulate a Bode plot. [5%]

ii. Design the notch filter, such that the peak in the magnitude of *P(s)* is trimmed in the Bode plot of (i). For validation, add a simulated Bode plot of the transfer function $C_{notch}(s)P(s)$ on the figure of (i). [15%]





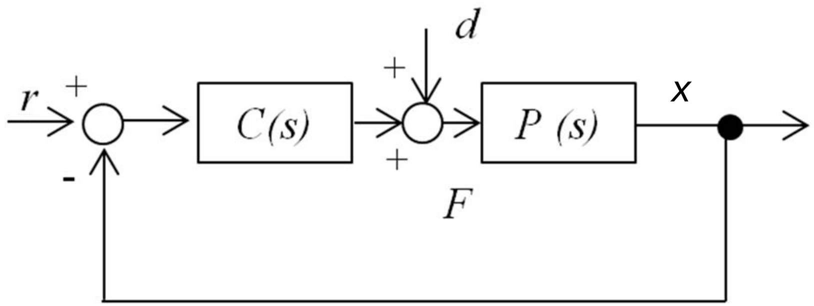
Computation Exercise 3(b)

iii. Design $C_I(s)$ to regulate the plant cascaded with the notch filter (i.e. $C_{notch}(s)P(s)$), fulfilling the following conditions. Also simulate a Bode plot of the open-loop transfer function $C_I(s)C_{notch}(s)P(s)$ for validation. [20%]

- Phase margin should be 40 deg or more.
- Gain margin should be 10 dB or more.
- The open-loop cross-over frequency should be as high as possible.

Computation Exercise 3(b)

iv. Simulate step response of the closed-loop system with *r* as the input and *x* as the output. Also draw step response with the disturbance *d* as the input and *x* as the output. Using the results, discuss the influence of the notch filter on these inputs. [20%]



There are two more questions. However, because they are control implementation problems, they will be explained on January 8th, 2015.