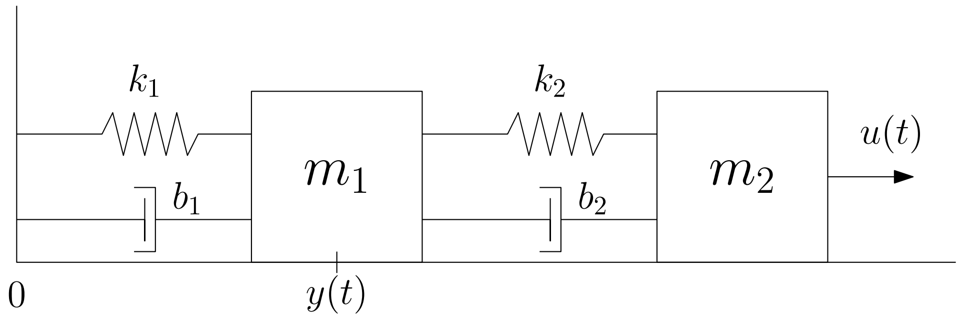
System Identification
Lab session #1 on System Identification

The mechanical device shown in figure consists in two coupled mass-spring-damper systems.



The continuous-time transfer function from the force $u(t)$ applied to the mass m_2, to the position $y(t)$ of the mass m_1 is given by:

$$G(s) = \frac{b_2 s + k_2}{m_1 m_2 s^4 + [(b_1 + b_2)m_2 + b_2 m_1]s^3 + [b_1 b_2 + k_2 m_1 + (k_1 + k_2)m_2]s^2 + (k_2 b_1 + k_1 b_2)s + k_1 k_2}$$

Consider the following numerical values of the physical parameters:

$$m_1 = 1,\ m_2 = 1,\ b_1 = 0.4,\ b_2 = 0.2,\ k_1 = 1,\ k_2 = 4$$

1. By using the Matlab command `c2d`, discretize the system $G(s)$ with sampling time $T_s = 0.1$, to obtain a discrete-time transfer function $G(z)$. Simulate the obtained discrete-time system for 50 seconds, with an input signal of type PRBS, generated through the Matlab command `idinput`. Plot the input/output data.

2. By using the input/output data obtained at point 1, identify several ARX models for the considered system, by changing the orders n_a and n_b of the polynomials $A(z)$ and $B(z)$ in the ARX equation. Compare the Bode plots of the estimated models with that of the true discrete-time function $G(z)$.

3. Repeat point 2, by using different model structures, such as ARMAX, OE and BJ.

4. Simulate the system again, by adding an output noise $e(t)$ to the output $y(t)$, so that

$$y(t) = G(z)u(t) + e(t)$$

   where $e(t)$ is a Gaussian white process with zero mean and variance 0.01. Repeat points 2 and 3 with the new input/output data, and observe the differences.