Computation exercise 1(b): Dynamics

Mechatronic systems
376.050
2014W

Important: Answers must be a hard copy and submitted to the office in CA0421 by 19th of November, 2014 at 4pm. The work must be original.

1. For the floating mass shown in Fig. 1, write the differential equation and obtain the transfer function from the force F to the position x. [10 %]

2. Fig. 2 shows a damped mass-spring system.

   i. Write the differential equation and derive the transfer function from the force F to the position x. Also calculate the un-damped natural frequency. [15 %]
   ii. Discuss the effect of the damping, comparing the two cases: no damping and low damping. [15%]

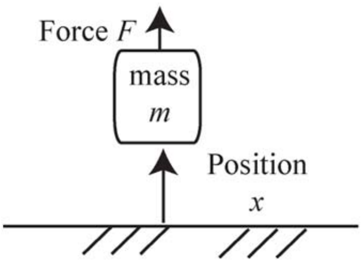

Fig 1. Floating mass.

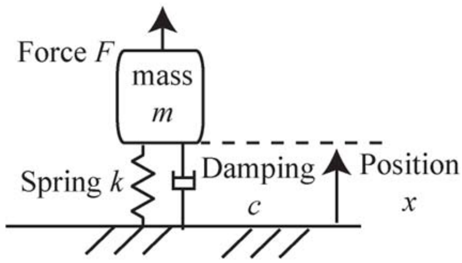

Fig2. Mass-spring system.

3. A positioning system using a piezoelectric actuator can be modeled as a lumped mass model in Fig.3, where piezo's stiffness and damping are represented by k_1 and c_1. The moving mass, m_1 and m_2 are connected by spring constant k_2 and damping coefficient c_2. The values of these parameters are given in Table1.

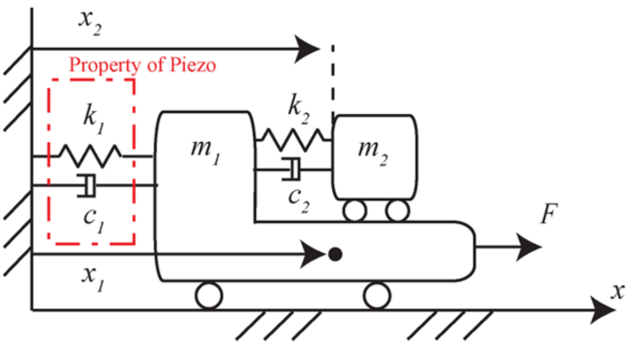

Table 1: Parameters

Parameter	Value	Unit
m_1	$1.5\text{x}10^{-3}$	kg
m_2	$0.1\text{x}10^{-3}$	kg
k_1	$70\text{x}10^{3}$	N/m
k_2	$10\text{x}10^{3}$	N/m
c_1	0.5	N/(m/s)
c_2	0.05	N/(m/s)

Fig. 3: A lumped mass model of a positioning system.

   i. Derive the differential equations for m_1 and m_2, respectively. [15 %]

   ii. Derive the transfer function from force F to position x_1 and x_2, respectively. [15 %]

   iii. Draw Bode plots of the transfer functions obtained in (ii) [15 %]

   iv. On the graph of the transfer functions in (iii), draw Bode plots of the following transfer functions. [15 %]

$$P_1(s) = \frac{1}{m_1 s^2 + c_1 s + k_1}, \qquad P_2(s) = \frac{1}{(m_1 + m_2)s^2 + c_1 s + k_1}$$