

University of British Columbia  
Department of Mechanical Engineering

MECH366 Modeling of Mechatronic Systems  
Homework 7

**Due: November 18 (Monday), 2019, 3pm**

To solve the following questions, if necessary, you can use a calculator.

1. For an unknown system, suppose that we applied a step input with amplitude 10 (i.e.,  $10u(t)$ ), and that the response was obtained as shown in Slide 16 of Lecture 17. Derive (roughly) the transfer function. Explain the derivation process in detail.
2. Let us consider the accelerometer in Slides 20–22 in Lecture 14. In this question, you do not need to re-derive the transfer function from the force  $F(s)$  to the displacement  $Y(s)$  of the proof-mass; just use

$$G(s) := \frac{Y(s)}{F(s)} = -\frac{1}{M} \cdot \frac{1}{s^2 + (b/m)s + (k/m)}.$$

For a vehicle mass  $M = 2,000$  [kg] and a proof-mass  $m = 0.002$  [kg], design the spring constant  $k$  [N/m] and damping constant  $b$  [Ns/m], to meet the following requirements. For a unit step input force,

**Requirement 1:** the percent overshoot (in this case, undershoot) is about 5%. (Hint: This corresponds to about 45 degree of the pole locations.)

**Requirement 2:** the 2% settling time is about 10 [ms] (fast enough, so that the airbag can inflate promptly after the collision).

(The obtained values might not be realistic, but this is just an exercise question.)