ECE 5610, Fall 2025, Additional practice problems.

1. Figure 1(a) shows the control system for an excavator, where $G(s) = \frac{1000}{s(s+10)(s^2+1.2s+1.44)}$. The oscillatory roots of $G(s)$ arise from compressibility of the hydraulic fluid and are often referred to as the *oil-mass resonance*. Assume that we use a computer based controller of the form:

$$D(z) = K\left[1 + K_v(1 - \frac{1}{z}) + K_a(1 - \frac{2}{z} + \frac{1}{z^2}\right]$$

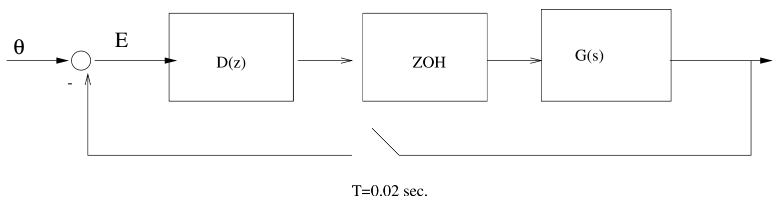

Figure 1: Block Diagram of an Excavator Control System

   (a) Show that the steady state error to a ramp is $e_{ss}^{\text{ramp}} = \frac{1.44}{K}$.
   (b) Determine the highest K that can be achieved using proportional control (i.e. $K_v = K_a = 0$).
   (c) Repeat (b) for PD control ($K_a = 0$).
   (d) Repeat (b) for PD + acceleration control (all $K_i \neq 0$).

2. Consider the system shown in Figure 2:

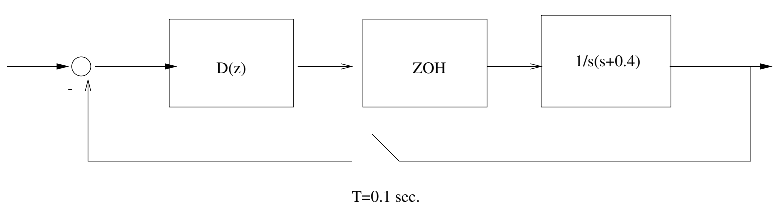

Figure 2: Block Diagram for Problem 2

Design a controller $D(z)$ so that the closed–loop system step response satisfies:

   (a) Rise Time $T_r \approx 0.5 sec.$
   (b) Overshoot $\leq 25\%$
   (c) $e_{ss}^{\text{step}} = 0$

Note: all of the specs above should be achieved *simultaneously*.