

## EEL 301 Homework #3

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**Question 1.** Consider the first-order system,

$$\frac{C(s)}{R(s)} = \frac{1}{Ts + 1}.$$

Find the response output  $c(t)$  when the input  $r(t)$  is a unit-ramp function ( $r(t) = t, t \geq 0$ , and zero otherwise). Sketch the response as a function of time.

**Question 2.** Consider the second-order system,

$$\frac{C(s)}{R(s)} = \frac{\omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2}.$$

Find and sketch the response output  $c(t)$  when the input  $r(t)$  is a unit-impulse function ( $R(s) = 1$ ), when

- a)  $0 \leq \zeta < 1$ .
- b)  $\zeta = 1$ .
- c)  $\zeta > 1$ .

**Question 3.** (Based on *Ogata, Problem B-2-4., Pg. 62*) For  $e(t) =$  unit-step function, sketch  $u(t)$ -versus- $t$  curves for the following five types of controllers,

- a)  $\frac{U(s)}{E(s)} = K_p$ .
- b)  $\frac{U(s)}{E(s)} = \frac{K_i}{s}$ .
- c)  $\frac{U(s)}{E(s)} = K_p \left(1 + \frac{1}{T_i s}\right)$ .
- d)  $\frac{U(s)}{E(s)} = K_p (1 + T_d s)$ .
- e)  $\frac{U(s)}{E(s)} = K_p \left(1 + \frac{1}{T_i s} + T_d s\right)$ .