Name:
ID. No.

<div style="text-align:center">

Eskişehir Osmangazi University - Electrical Engineering Department
Fundamentals of Control Systems
Midterm Examination - Spring 2017

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All answers must be written in the appropriate neighborhoods of the questions. Anything written else-where will not be graded. Use the back side of the exam sheet if you need scratch paper.
Duration: 65 min., Calculator is allowed, An A4 size sheet (both sides for any content) is allowed.

Question 1.

Let the LTI system configuration on the right have the com-ponent transfer functions $G_1(s) = \dfrac{1}{s}$ *and* $G_2(s) = \dfrac{1}{s+1}$.
Write the transfer function $\dfrac{E(s)}{R(s)}$.
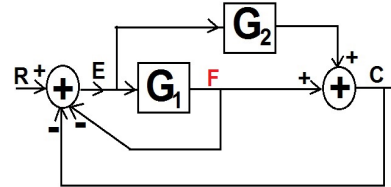
$$\frac{s^2 + s}{s^2 + 4s + 2}$$

Details: $E = R - C - F; F = G_1 E; C = G_2 E + F; \rightarrow \dfrac{E}{R} = \dfrac{1}{1 + 2G_1 + G_2} = \dfrac{s^2 + s}{s^2 + 4s + 2}$
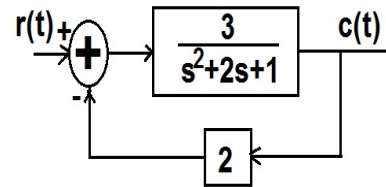
Question 2.

For the LTI system configuration on the right let the input r be a step function with amplitude 5.
(a) Write the steady state value of the output c.
(b) Write the rise time of the output c.
1% error in the answers is tolerable.

a) $\dfrac{15}{7}$; *Details:* $\dfrac{C}{R} = \dfrac{3}{s^2 + 2s + 7}, \lim_{s \to 0} s \dfrac{3}{s^2 + 2s + 7} \dfrac{5}{s} = \dfrac{15}{7}$

b) $t_r = 0.7995$; *Details:* $t_r = \dfrac{\pi - \beta}{w_d}, \beta = \cos^{-1} \dfrac{1}{\sqrt{7}} = 1.1832; w_d = \sqrt{7}(1 - (\dfrac{1}{\sqrt{7}})^2)^{\frac{1}{2}} = 2.4495$
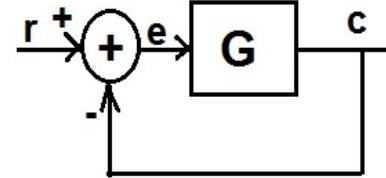
Question 3.
[No partial credits] Let the LTI system configuration on the right have the component transfer function
$G(s) = \dfrac{4(3s + 1)(4s + 1)}{s^4(6s + 1)(8s + 1)(9s + 1)}$. *For the following in-puts write the steady state errors.*
(a) $r(t) = t^2 u(t)$ *Ans.* 0
(b) $r(t) = t^3 u(t)$ *Ans.* 0
(c) $r(t) = t^4 u(t)$ *Ans.* 6
.

$$Details: \ e_{ss} = \lim_{s \to 0} s \frac{1}{1 + G} R(s) \ with \ a) \ R(s) = \frac{2}{s^2}, \ b) \ R(s) = \frac{6}{s^4}, \ c) \ R(s) = \frac{24}{s^5}$$

ps. Details are not needed in the answers; they are included for educational purpose.
Good Luck
A. Karamancıoğlu