ELEN90055 Control Systems
Worksheet 3
Semester 2

Instructions

This worksheet covers materials about *block diagram algebra, stability criterion* and *steady state error*. Solutions to starred problems in part 1 (tutorial problems) will be provided to students after the tutorial. Additional solved problems are provided in part 2. Students are encouraged to work on the solutions to the problems in parts 3 and **??** by themselves.

1 Tutorial problems

1*. Find the transfer function $H(s) = \frac{Y(s)}{R(s)}$ for the feedback system shown in Figure 1.

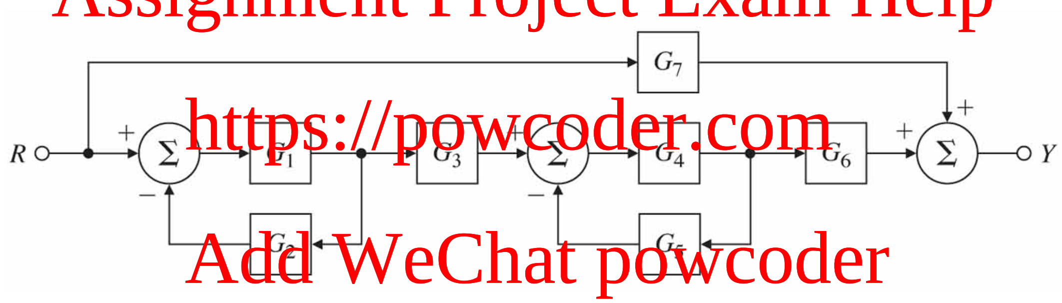

Figure 1: Problem 1.

2*. Consider the system shown in Figure 2. This system contains a delay, indicated by the non-rational transfer function e^{-sT}.

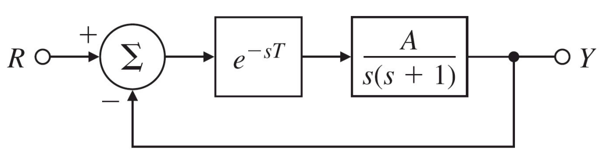

Figure 2: Feedback system with a delay.

(a) Determine the closed loop characteristic equations. *Note:* this will include the delay term e^{-sT}.

(b) Use the following approximation to the delay function and determine values for T and A such that the system is stable.

$$e^{-sT} \approx \frac{1 - \frac{T}{2}s}{1 + \frac{T}{2}s}$$

3*. Consider the closed-loop system in Figure 3 representing the block diagram of a DC motor where k, K, and J are positive, and let $r(t) = \mathscr{L}^{-1}\{R(s)\}$ be a unit step function. Compute the initial value and the final value of the output.

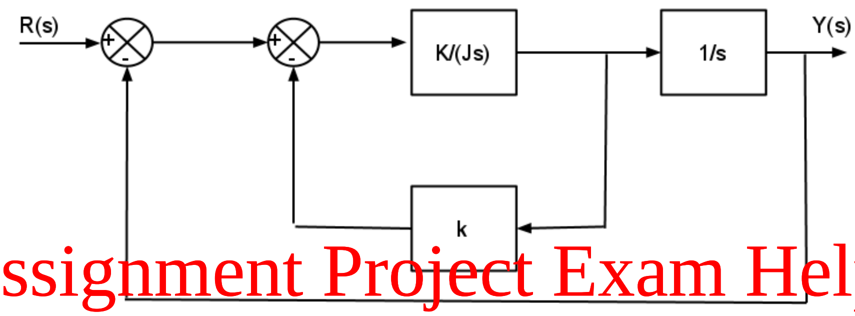

Figure 3: Problem 3

4*. For the unity feedback system in Figure 4 with

$$G(s) = \frac{4(s+1)}{s^2(s+2)}$$

find the steady-state error when the input is

(a) $r(t) = 1$.

(b) $r(t) = t$.

(c) $r(t) = t^2$.

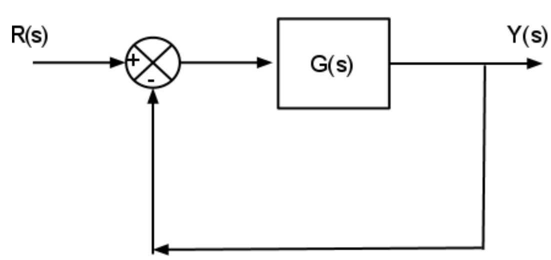

Figure 4: Problem 3

5*. Consider the system shown in Figure 5 where $D(s) = s + k$, $R(S)$ is the reference input and $W(s)$ is a disturbance.

(a) Find the transfer functions from R to Y and from W to Y.

(b) What conditions must k satisfy such that the system is stable.

(c) Let $R(s) = W(s) = 1/s$. Is it possible to choose the parameter k such that the steady state error of the system from $r(t) = 1$ and also the steady state output from the disturbance $w(t) = \mathscr{L}^{-1}\{W(s)\}$ are zero?

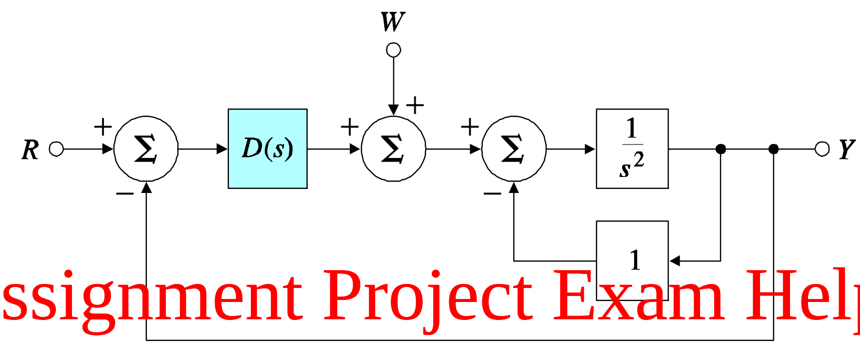

Figure 5: Problem 5

6. Suppose that unity feedback is to be applied around the open-loop systems listed below (so the closed-loop system is similar to Figure 4. Use Routh's stability criterion to determine whether the resulting closed-loop systems will be stable.

(a)

$$G(s) = \frac{4(s+2)}{s(s^3 + 2s^2 + 3s + 4)}$$

(b)

$$G(s) = \frac{2(s+4)}{s^2(s+1)}$$

(c)

$$G(s) = \frac{4(s^3 + 2s^2 + s + 1)}{s^2(s^3 + 2s^2 - s - 1)}$$

2 Additional solved problems

1. Solved Problems 4.3, 4.9, 5.5 from the solved problems of the *web site for Goodwin, Graebe, Salgado 'Control System Design'* - see Example problems with worked solutions at http://www.csd.elo.utfsm.cl/.

3 Previous exam questions

1. Q2(ii) part (a); Control system final exam 2013.
2. Q3(d) the fist part and Q3(e); Control system final exam 2015.