Control Systems

(Prof. Casella)

Final Exam – June 26th, 2015

Surname:..

Name: ....

Reg. Number:...............................

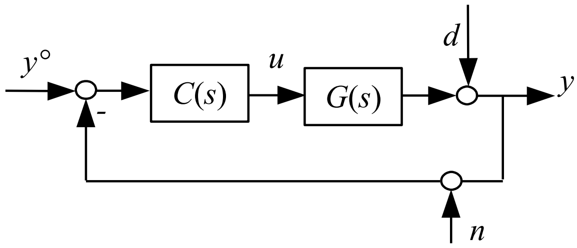
Signature:.....................................

Notices:

- This booklet is comprised of 6 sheets – Check that it is complete and fill in the cover.
- Write your answers in the blank spaces with short arguments, including only the main steps in the derivation of the results.
- You are not allowed to leave the classroom unless you hand in the exam paper or withdraw from the exam.
- You are not allowed to consult books or lecture notes of any kind.
- Please hand in only this booklet at the end of the exam – no loose sheets.
- The clarity and order of your answers will influence how your exam is graded.

Question 1

Consider the control system shown in the figure. Define the *control sensitivity* transfer function and explain why is it important to assess the system performance. Finally, explain how to approximate its frequency response assuming that the loop transfer function satisfies the pre-conditions of Bode's criterion.



Question 2

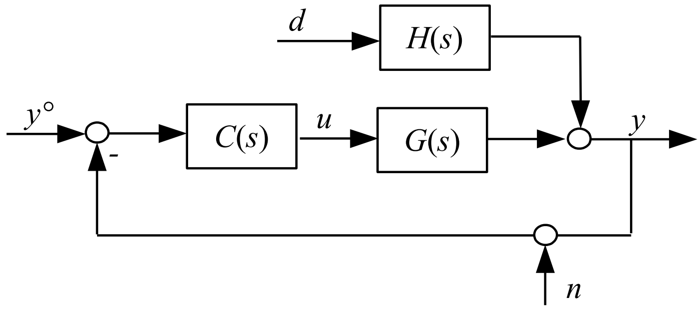
Draw the block diagram of a 2-degrees-of-freedom controller using set-point pre-filtering. Briefly explain the design criteria for the controllers.

Question 3

Consider the following control system (time constants are given in seconds), where $C(s)$ is a real PID controller with $K_p = 50$, $T_i = 100$, $T_d = 20$, $N = 3$:

$$G(s) = \frac{0.15}{(1+100s)(1+20s)(1+5s)(1+2s)}$$

$$H(s) = \frac{4}{s(1+100s)}$$



3.1 Compute the steady-state errors corresponding to unit step changes of the set point $y°$ and of the disturbance d.

3.2 Compute the crossover frequency and the phase margin of the control system. Then, plot an approximated diagram of the step response of the controlled variable y to a step change of the set point $y°$.

3.3 Compute the asymptotic amplitudes of the oscillations of the manipulated variable u and of the controlled variable y corresponding to a sinusoidal feed-back disturbance n having unit amplitude and a period of 0.1 seconds.

3.4 Plot an approximated diagram of the response of the controlled variable y to a step change of the disturbance d.

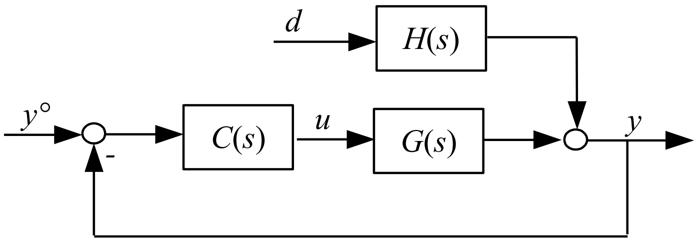
3.5 Explain how the static and dynamic system performance changes if the actual gain of $G(s)$ turns out to be ½ of its design value, using the same controller.

Question 4

Consider the following control system, where the unit of time constants is the second:

$$G(s) = 0.1\frac{e^{-10s}}{(1+3s)(1+0.5s)}$$

$$H(s) = 0.5\frac{e^{-10s}}{1+3s}$$



4.1 Design a PI or PID controller with a bandwidth of 0.04 rad/s and a phase margin of at least 60°.

4.2 Design a disturbance compensator to improve the disturbance rejection in the frequency range 0–0.4 rad/s

Question 5

5.1 Draw the block diagram of a cascaded controller and briefly discuss its design criteria

5.2 Discuss what are the advantages and disadvantages of this control strategy compared to a standard feedback controller applied to the same plant.