ELEC 372 - Homework 4

(To be submitted on Moodle by August 8th, 11:59PM)

Note:

- By the given deadline, upload a report (in pdf format) containing the solutions to problems below. Late reports will not be accepted.
- For problems solved by hand, include in the report all the steps of the solution.
- For problems requiring the use of Matlab/Simulink, include in the report the obtained results. Upload also the used/developed Matlab and Simlulink files, collecting them in a single zip folder. The uploaded Matlab/Simulink files must be working.
  Plots and figures (e.g., generated in Matlab/Simulink) can be included in the report to better describe/comment the obtained solutions.

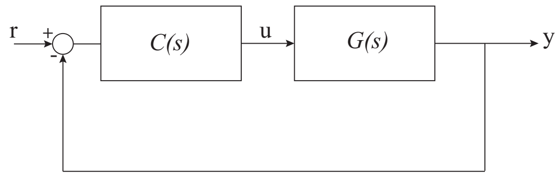

Figure 1: Closed-Loop Control System

Problem 1 (6 points)**.** Consider the feedback control system shown in Fig. 1 where

$$G(s) = \frac{s+2}{(s+1)(s+4)(s+5)(s+9)}$$

In Matlab, using *rltool*, design $C(s)$ such that

- The steady-state tracking error due to a step reference signal is zero[1]
- The step response of the closed-loop system has a settling time $T_s(98\%) \leq 3$ sec
- The step response of the closed-loop system has an overshoot $\%OS \leq 15\%$

Hints:

- *The command rltool(G) opens a new window with two different plots: the root-locus and the step response.*
- *rltool(G), by default, considers a controller $C(s) = K$.*
- *By right-clicking on the root-locus plot, it is possible to:*
  - *add new poles and zeros in $C(s)$*
  - *add the desired closed-loop pole region that achieve the given specifications. To this end: → design requirements → New → (add here the desired requirement).*[2]
- *Moving the closed-loop poles location (i.e., the poles shown as pink squares ▪) is equivalent to change the gain K of $C(s)$.*
- *Once the controller design is terminated, it is possible to export $C(s)$ into the Matlab workspace by clicking on Export (on the top panel) → Export tuned blocks → check the C box → export.*

[1] This specification defines the number of poles in the origin (system's type) that must be in $C(S)G(s)$ to obtain zero tracking error.

[2] The tool finds the desired closed-loop pole region considering a second order underdamped system. However, the considered system is not. A way to address this possible issue is to ensure that the closed-loop poles are within the desired region with a certain tolerance margin.

Problem 2 (4 points)**.** Consider the following transfer function:

$$G(s) = 10\frac{s+100}{(s-10)(s+1)}$$

Draw on a paper the asymptotic Bode plots (modulus and phase) of $G(j\omega)$