16.060 Principles of Automatic Control **Fall 2002**
Final Exam

Part A: Put your working and answers in the booklet provided.

Question A.1
20 points

Consider the plant

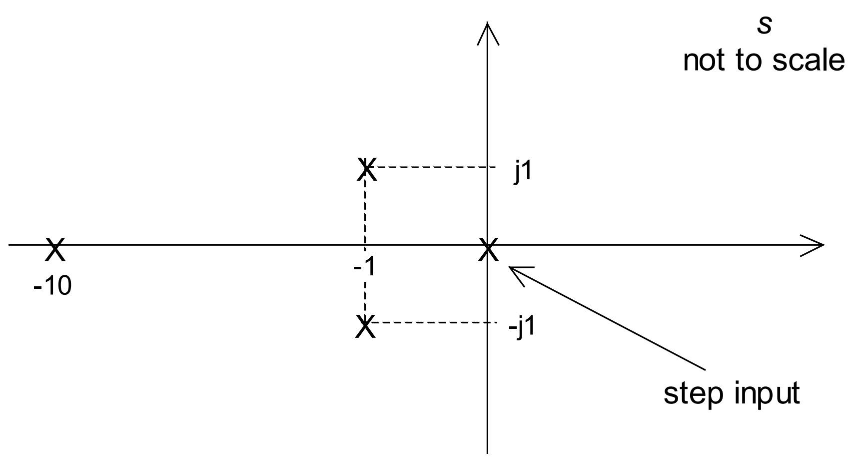
$$G(s) = \frac{1.25}{s^2 + s + 1.25} = \frac{1.25}{(s + 0.5 - j)(s + 0.5 + j)}$$

a) The desired closed-loop performance specifications are: $\zeta = 0.707, \quad \omega_n = \sqrt{8}$. Where should the closed-loop poles be located?
b) Using root-locus techniques, design a PD controller that satisfies the above performance requirements.
c) What will be the steady-state error of your compensated system to a unity step input?

Question A.2

20 points

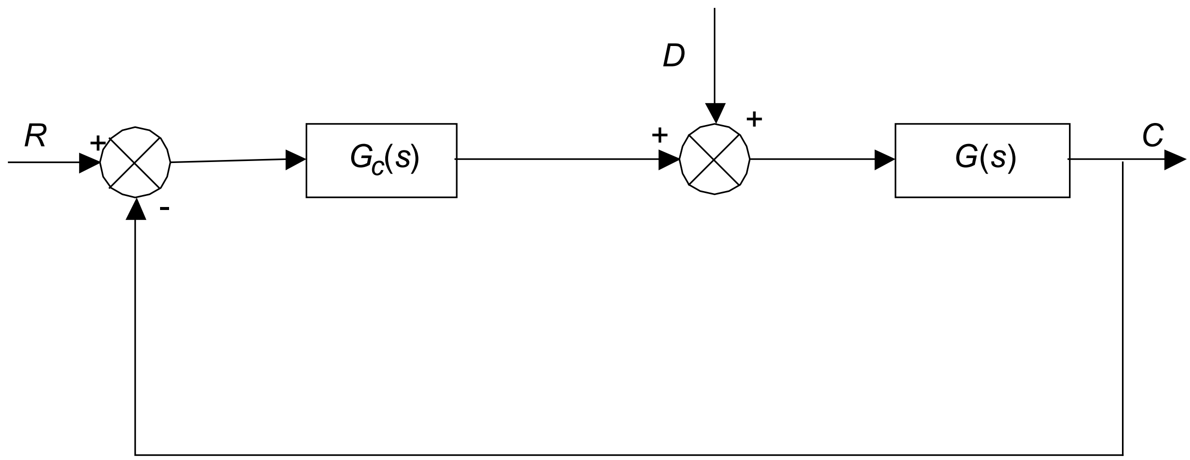
Consider the system represented by the following pole/zero diagram, where the pole at the origin represents a step input. The system has unity gain (i.e. the steady-state input/output gain is 1).



a) Calculate the magnitude of all residues.
b) What is the time constant associated to each mode?
c) Write down an exact expression for the step response.
d) Is there a dominant transient mode? If so, which mode is dominant? Justify your answer.

Question A.3
20 points

Consider the following system



The plant is given by $G(s) = \dfrac{2}{s(s^2+2s+2)} = \dfrac{2}{s(s+1-j)(s+1+j)}$.

Consider P-control, i.e. $G_c(s)=K$.

a) Draw the root-locus of the system for $K>0$. Calculate the angles of departure from the complex poles.

a) Calculate K_{crit}, the value of K for which the closed-loop system becomes unstable.

b) Consider a unity disturbance step input, i.e. R(s)=0, D(s)=1/s. What is c_{ss}, the steady-state response of the closed-loop system?

c) The design specifications require that the steady-state step disturbance response calculated in Part (c) above is less than 10%, i.e $c_{ss}<0.1$. Will the proportional controller work? If so, give the controller design; if not, give an explanation.

Question A.4

20 points

Answer true or false to the following:

a) A simple lag mode with pole close to the imaginary axis is a 'fast' mode, i.e. it decays quickly.

b) A system with feedback that has zero steady-state error for a step input must also have a zero steady-state error for a step disturbance.

c) A zero on the real axis close to a pair of complex conjugate poles tends to reduce the percentage overshoot of the step response.

d) A zero on the real axis close to a simple lag pole tends to reduce the transient contribution of that pole.

e) For a phase-lead compensator, the compensator zero is closer to the origin than the compensator pole.

Answer the following:

f) State two reasons for the use of feedback.

g) Why might it be beneficial to include an integrator in your controller design?

h) State two reasons why a closed-loop transfer function might contain one or more zeroes.

i) In a motor position servo, physically, to what does the 'D' part of PD-control correspond?

j) Which of the following are affected by changing the real part of a complex conjugate pole pair: percentage overshoot, settling time, undamped natural frequency, peak time.