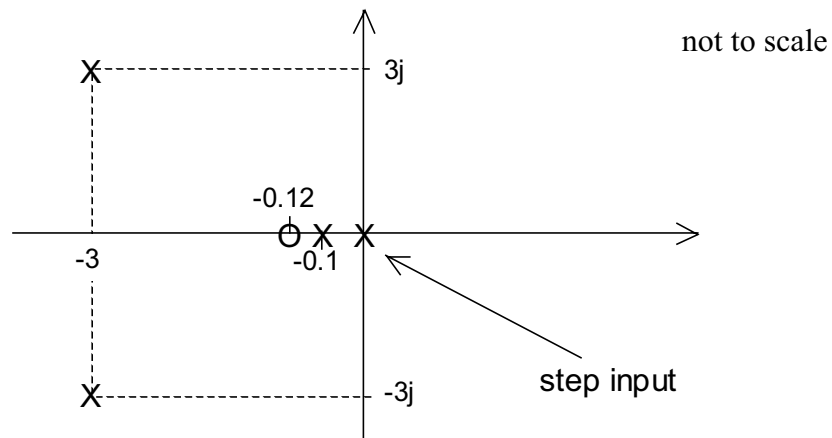


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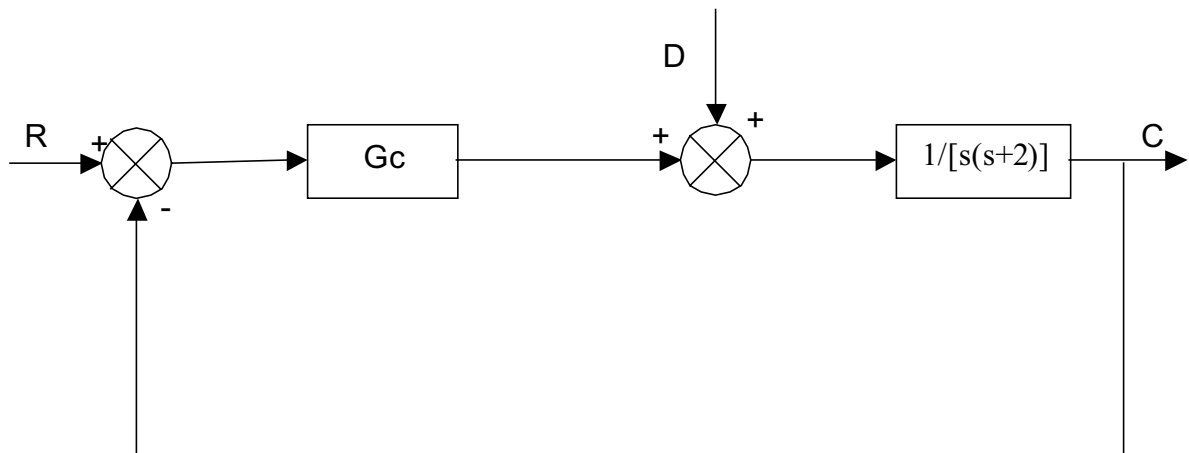
2. Consider the system represented by the following pole/zero diagram, where the pole at the origin represents a step input. The system has unity gain.



- Write down the form of the step response $c(t)$. No numbers are necessary for the residue magnitudes and angles, but define your notation.
- What is the root locus gain of the system?
- Calculate the magnitude of each of the residues.
- What is the decay time of each exponential mode?
- Is there a dominant mode or modes? Explain the rationale for your answer in a few words.

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3. Consider the following system with controller G_c , reference input R , and disturbance input D :

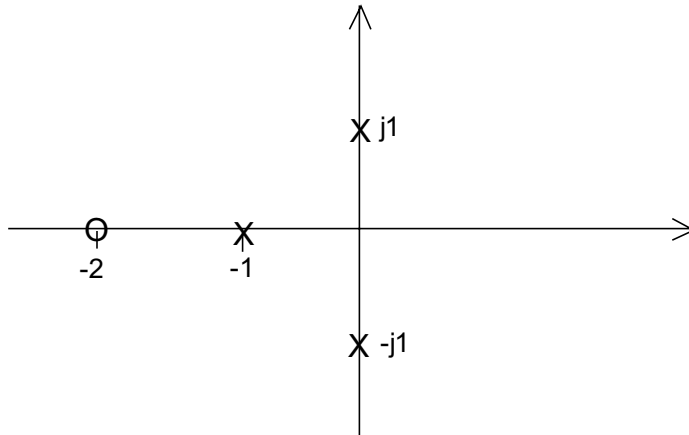


- If G_c is a proportional controller, $G_c = K_c$, what value of K_c will cause the steady-state error for a unit ramp reference input to be 0.1?
- If we want a zero steady-state error for a unit ramp reference input, what form should the controller G_c take?
- For a unit step disturbance input, what form of controller G_c should we choose to make the steady-state error zero?
- Assume that the reference input is a unit step, the disturbance input is zero and we are using a proportional controller. What value (or values) of K_c will yield an underdamped system with a settling time of 4 seconds?
- Considering the same case as part d, what effect does increasing K_c have on the damping ratio?

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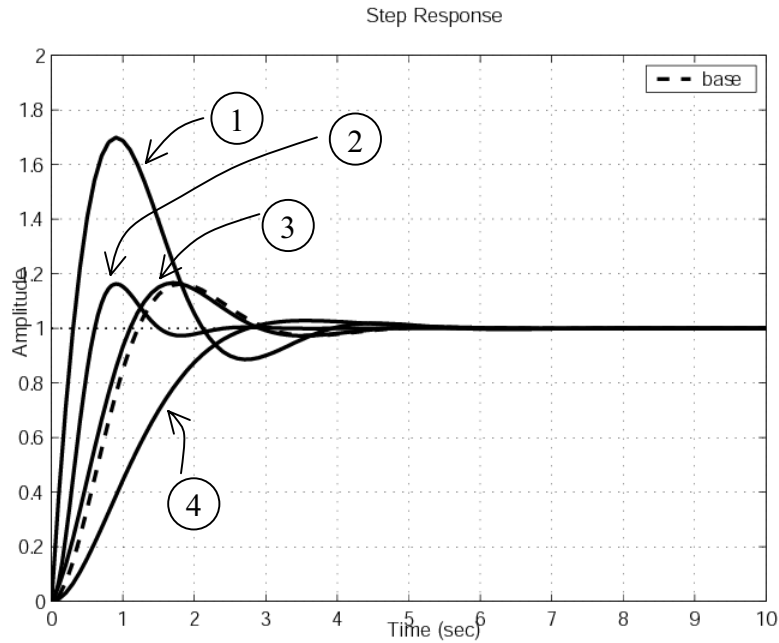
4.

For the system shown below, sketch the root locus for $K > 0$ and $K < 0$ on separate plots. Where appropriate, calculate ρ_0 and the angles of departure of the complex poles.



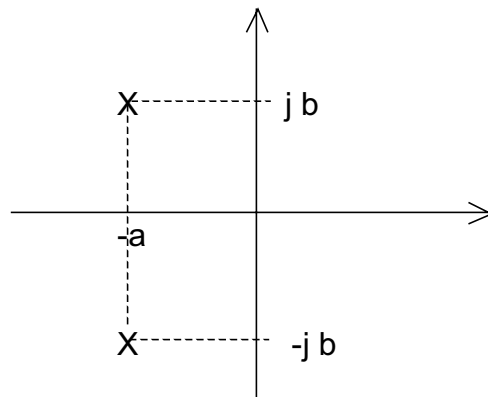
NAME:

5. The following plot shows the response of 5 different systems to a unit step input. The dashed lines indicate the response of the baseline system.



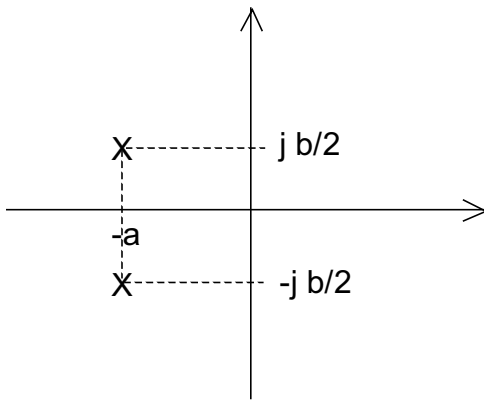
Consider the baseline pole-zero diagram shown below and the four modified pole-zero diagrams shown on the next page. Each diagram corresponds to one of the responses shown above. For each of the four modified systems, match the step response to the pole-zero diagram. Justify your choice with a few words.

Baseline:



NAME:

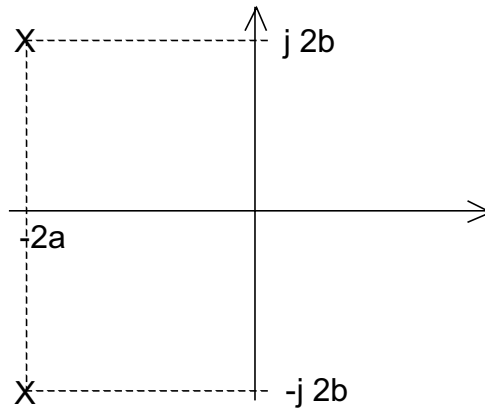
Pole-zero diagram 1:



Which response?

Why?

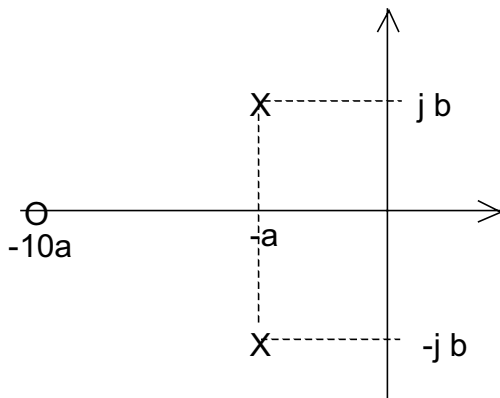
Pole diagram 2:



Which response?

Why?

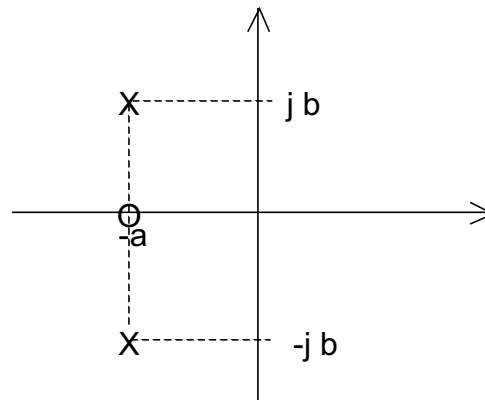
Pole-zero diagram 3:



Which response?

Why?

Pole diagram 4:

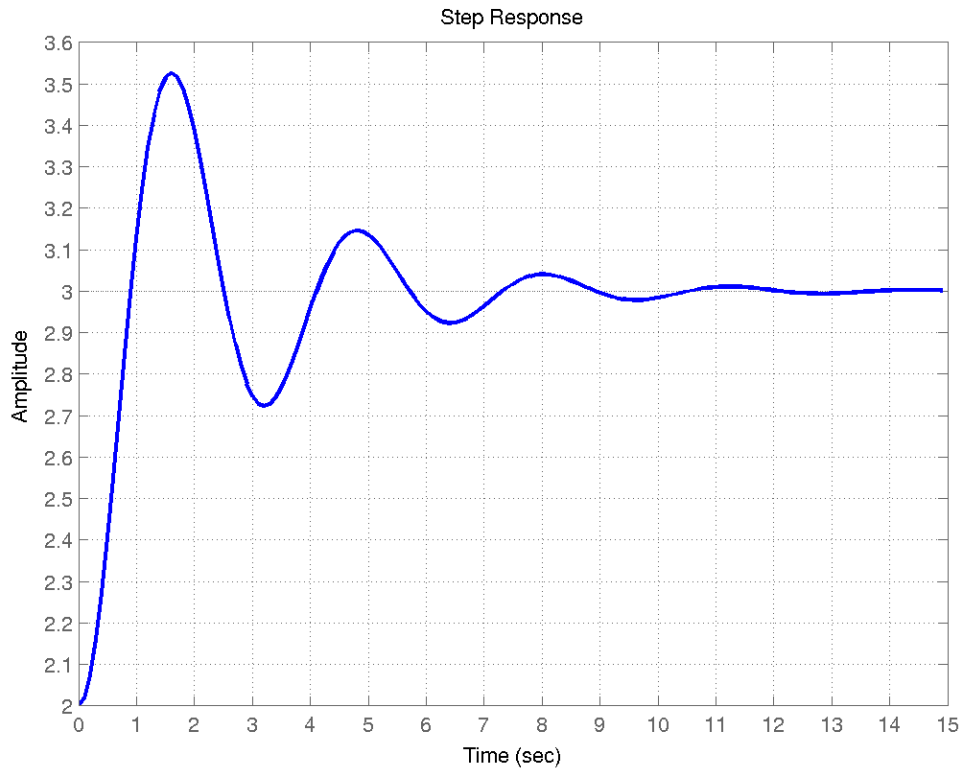


Which response?

Why?

NAME:

6. The following plot shows the response of a second-order system to a unity step input applied at $t=0$. At $t=0$, the system was in its equilibrium position.



- What is the 5% settling time (T_s)?
- What is the percentage overshoot (P.O.)?
- What is the peak time (T_p)?
- What is the rise time (T_r)?
- What is the damped natural frequency (ω_d)?
- What are the locations of the poles?