Instrumentation and Control Systems
Mock exam

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No blank pages.
You are welcome.

Section One:

Part A:

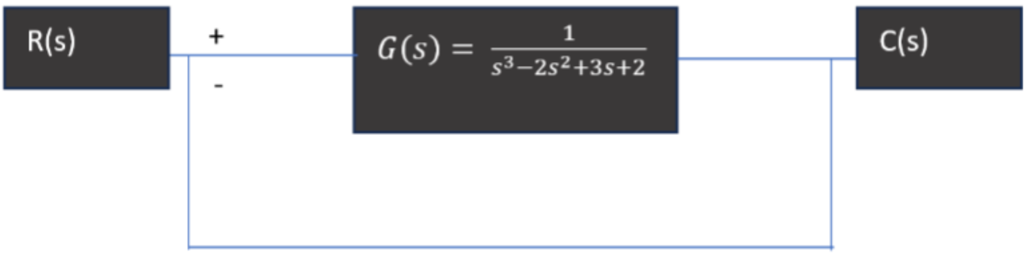
Solve the following system of equations using Laplace Transform. Assume initial conditions to be zero.

$$\frac{d^2x}{dt^2} + 4x = 6y$$

$$\frac{d^2y}{dt^2} - 3x + 8y = 10t$$

Part B:

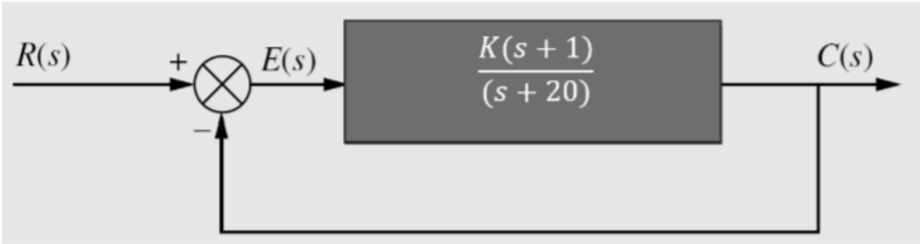
Generate a Routh Table for the closed loop system in the figure below and determine if the system is stable, marginally stable, or unstable.



Section Two:

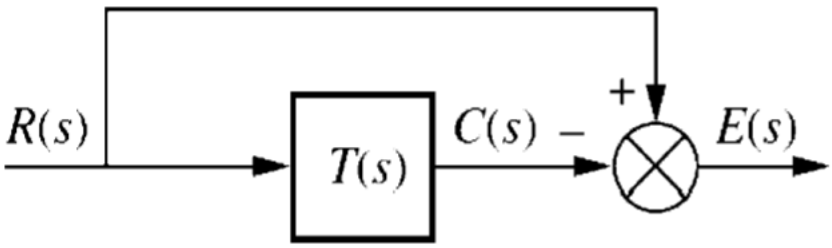
Part A:

Find the value of k such that there is a 20% error in steady state.



Part B:

Find the value of steady state error for a unit step input if $T(s) = s$



Part C:

Find the value of steady state error component due to ramp disturbance $tu(t)$, if transfer function of plant is $\frac{1}{s(s+5)}$ and that of the controller is $\frac{1}{s}$

Section Three:

Part A:

Select one correct option from the following:

1. The derivative term of a PID controller helps to:
   A: Eliminate steady state error.
   B: Reduce the control effort.
   C: Predict the future error.
   D: Reduce overshoot.
2. What is the primary purpose of the integral term in a PID controller?
   A: To improve transient response.
   B: To reduce steady state error.
   C: To provide predictive control.
   D: To minimize overshoot.
3. What is the primary drawback of using a very high integral gain in a PID controller?
   A: Reduced steady state error.
   B: Increased overshoot.
   C: Slower transient response.
   D: Reduced control effort.
4. True or false:
   "An integrator sums error over time to provide a continuous correction and improves the transient response".
5. True or false:
   "Overshoot value is used to calculate the natural frequency of a system"

Part B:

Consider a unity feedback system with the forward transfer function:

$$G(s) = \frac{50}{(s+24)(s^2+8s+14)}$$

Design a PD controller to achieve 20% overshoot in the closed loop step response with a settling time of 1 second.

Part C:

Design a PI controller for the compensated system in Part B to reduce the overshoot by 10% while allowing the settling time to increase by 20%. Display the transfer function of the PID controller by putting the values of K_p, K_i, and K_d.

Section Four:

Part A:

Draw the bode plot for the system with transfer function:

$$G(s) = \frac{20}{s(s+10)(s+12)}$$

and design a proportionality controller with phase margin $\geqslant 50\%$

Part B:

For a closed loop unity feedback system with transfer function

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

find the gain of the controller required to achieve a damping ratio of 0.5, find the percent error in overshoot for the compensated closed loop system.