# Control Systems

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Abstract—This manual is an introduction to control systems based on GATE problems.Links to sample Python codes are available in the text.

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## 1 Mason's Gain Formula

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3.1 Damping	
3.2 Example	
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3.1. A second-order real system has the fo properties:	llowing
a) the damping ratio $\zeta = 0.5$ and unc	damped
natural frequency $\omega_n = 10 rad/s$	•
b) the steady state value of the output, to a unit	
step input, is 1.02.	
The transfer function of the system is $\frac{102}{102}$	
(A) $\frac{1.02}{s^2 + 5s + 100}$ (B) $\frac{102}{s^2 + 10s + 100}$ (C) $\frac{100}{s^2 + 10s + 100}$ (D) $\frac{102}{s^2 + 5s + 100}$	
(C) $\frac{100}{s^2+10s+100}$ (D) $\frac{100}{s^2+5s+100}$	
<b>Solution:</b> Characteristic equation of	second
order system is as follows	
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$s^2 + 2\zeta\omega_n s + \omega_n^2 = 0$	(3.1.1)
Given	
$\zeta = 0.5$	(3.1.2)
$\omega_n = 10 rad/s$	(3.1.3)
Therefore the equation becomes	
$s^2 + 10s + 100 = 0$	(3.1.4)

Denominator of the Transfer Function is characteristic equation. Considering this, we can eliminate A and D options.

We know that output of the system in s domain is

(3.1.5)

$$C(s) = T(s)R(s)$$
 (3.1.6)

$$R(s) = \frac{1}{s}$$
 (3.1.7)

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as it is unit step input.

Steady state output is given by

$$C(\infty) = \lim_{s \to 0} sC(s) \tag{3.1.8}$$

Given, steady state output is 1.02 and is the same for only option B

Therefore, transfer function of the system is

$$\frac{102}{s^2 + 10s + 100} \tag{3.1.9}$$

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