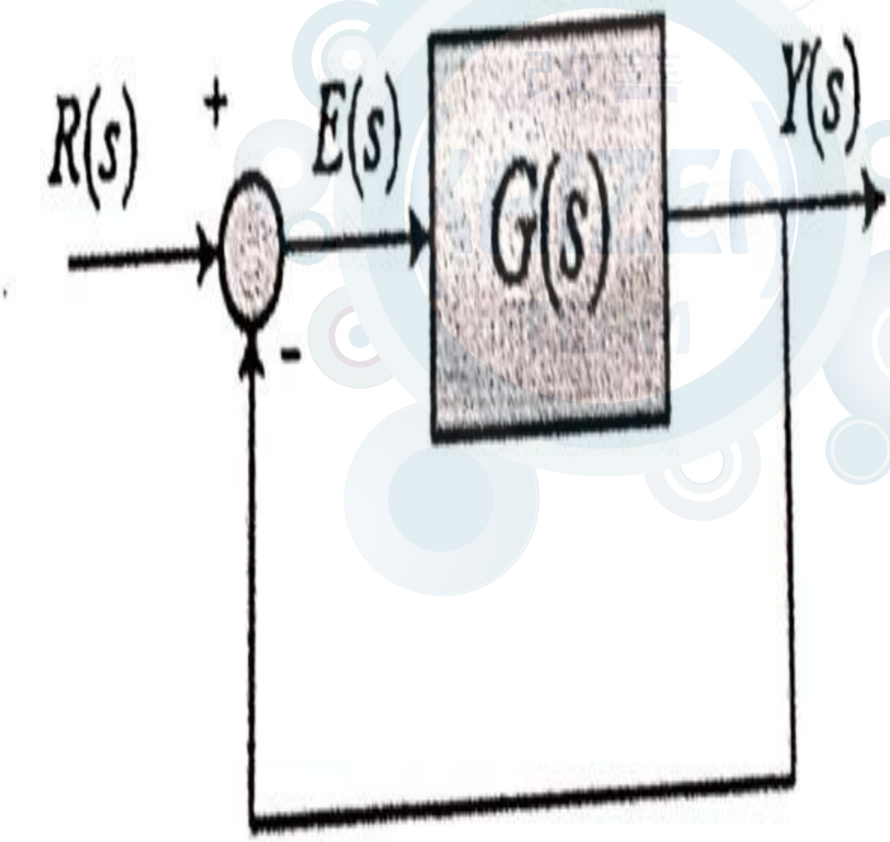
Name

Q1) find the K value to achieve a steady state error 0f < 0.1 for a unit step input

$$G(s) = \frac{K(s+1)}{(s+5)(s+7)}$$



④ step input $e < 0.1$

finite $\quad$ $e = 0$

when $N = 0$ $\quad$ when $N \geq 1$

$$K_p = \lim_{s \to 0} \frac{K(s+1)}{(s+5)(s+7)} \qquad \lim_{s \to 0} \frac{K}{s} \frac{(s+1)}{(s+5)(s+7)} = \infty$$

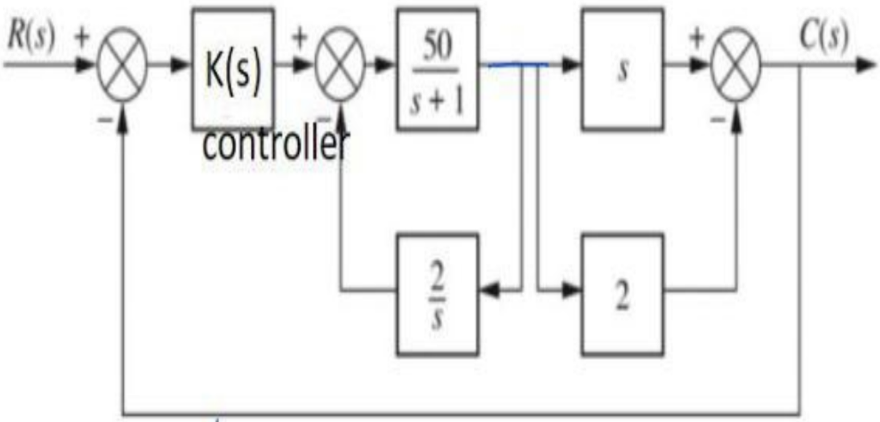
$$= \frac{K}{35} \qquad e = \frac{1}{1+K_p} = 0$$

$$\frac{1}{1+\frac{K}{35}} < 0.1 \qquad K \text{ if } K > 315 \left\{ \begin{array}{l} \frac{K}{s} \\ 0 < K \end{array} \right.$$

$$1 + \frac{K}{35} > 10$$

$$\frac{K}{35} > 9$$

$$K > 315$$



$$\frac{\frac{50}{s+1}}{1+\frac{2}{s}\cdot\frac{50}{s+1}}$$

$$e_{ss} < 2$$

$$\frac{1}{K_v} < 2$$

$$\frac{K(s)\,50\,s}{(s+1)+100} \cdot (s-2)$$

$$K_v = \lim_{s \to 0} \cancel{s}\,\frac{K(s)\,50\cancel{s}\cdot(s-2)}{\cancel{s}^2(s+1)+100} \qquad \frac{K(s)\,50(-2)}{101}$$

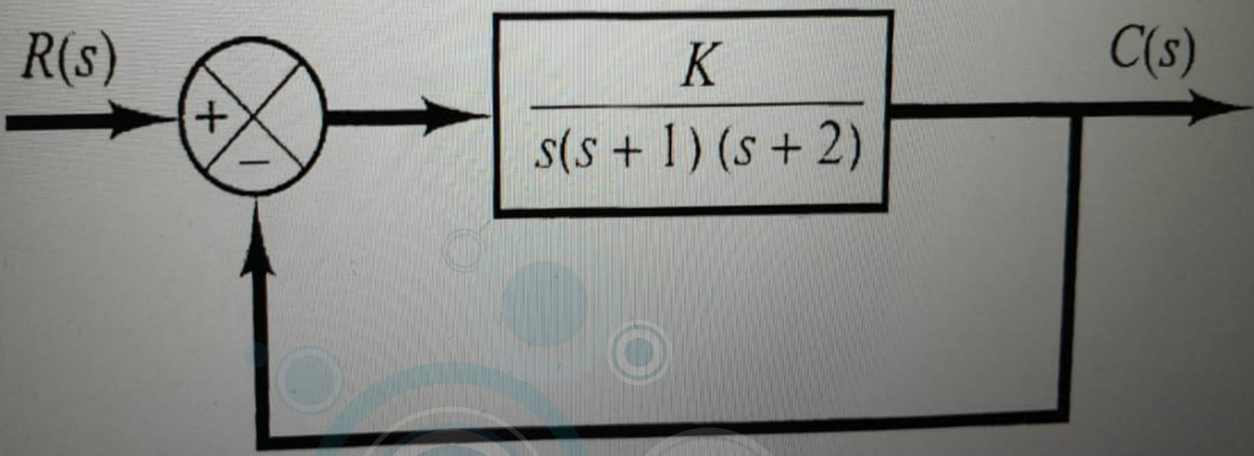
$$\frac{1}{K(s)\ -0.99} < 2$$

$$\boxed{\frac{0.99}{s^2} < K(s)}$$

Quiz 4 Industrial control systems Prof. M. Barghash IE dept SoC UoJ 13/11/2024

Name ID:

For following system what is the steady state error for R= 3u(t) +5t



$$\boxed{\frac{3}{1+K_p} + \frac{5}{K_v} = \frac{3}{\infty} + \frac{5}{\frac{K}{2}} = 0 + \frac{10}{K}}$$

$$K_p = \lim_{s \to 0} \frac{K}{s(s+1)(s+2)} = \frac{K}{0} = \infty$$

$$K_v = \lim_{s \to 0} \cancel{s} \times \frac{K}{\cancel{s}(s+1)(s+2)} = \frac{K}{2}$$

ID:

rise time for the following system

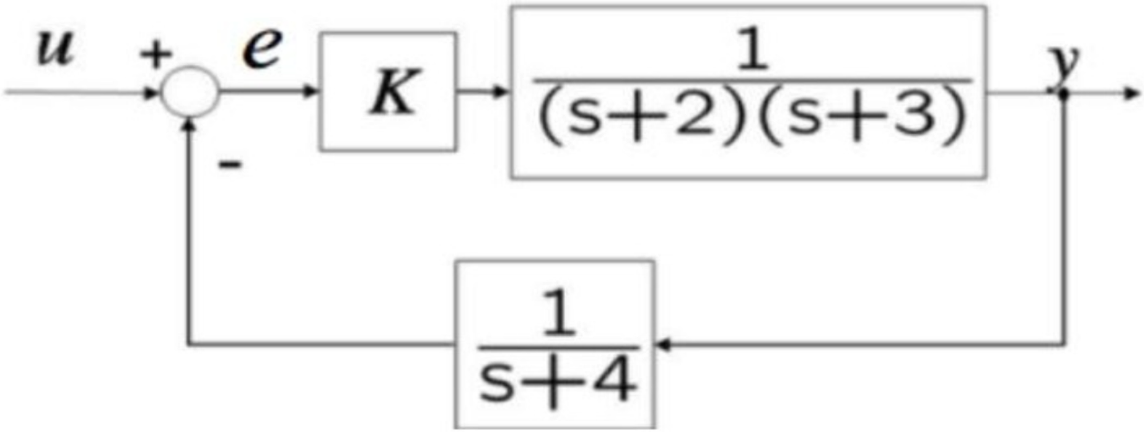
$$G(s) = \frac{7}{s^2 + 14s + 40}$$

$(s+4)(s+10)$

$T_r = 2.2\,\tau = 0.55$

$\tau = \frac{1}{a} = \frac{1}{4}$

Q2) calculate the steady state error if u(t) = 3t^2



التاريخ :

الموضوع :

$$y = e\,\frac{K}{(S+2)(S+3)} \quad (1)$$

$$u = 3t^2 \qquad 3\,\frac{2!}{S^3}$$

$$e = u - \frac{y}{S+4}$$

$$e\left(1 + \frac{K}{(S+2)(S+3)(S+4)}\right) = u$$

$$e = u - \frac{eK}{(S+2)(S+3)(S+4)}$$

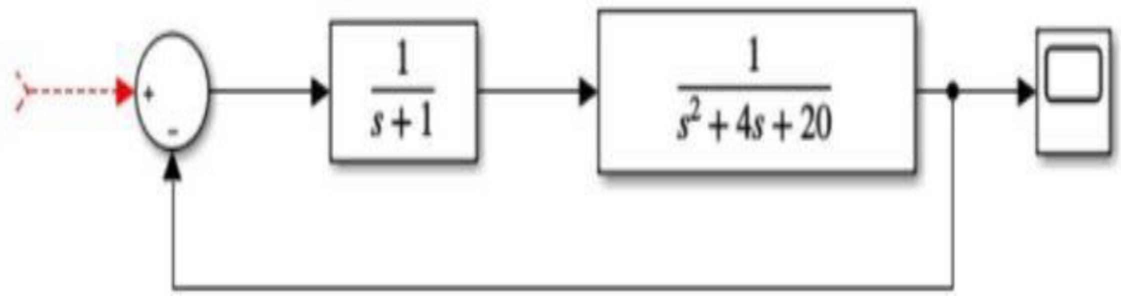
$$e\,\frac{(S+4)*(S+2)(S+3)+K}{(S+2)(S+3)(S+4)} = u$$

$$e = \frac{u\,(S+2)(S+3)(S+4)}{(S+4)(S+2)(S+3)+K}$$

To find Final Value

$$e = \lim_{S \to 0} \frac{\cancel{s}\,6\,(S+2)(S+3)(S+4)}{s^{\cancel{3}}\left((S+2)(S+3)(S+4)+K\right)} = \infty$$

Q2 a) (2.5 points) Find the steady state error to a step input the following



Solution

$$K_p = \lim_{s\to 0} \frac{1}{s+1}\,\frac{1}{s^2+4s+20} = \frac{1}{20}$$

$$e = \frac{1}{1+K_p} = \frac{1}{1+\frac{1}{20}} = \boxed{\frac{20}{21}}$$

Controller

k

Ess=..

b)(2.5 points) For the a part design add a controller to achieve steady state error = 1; when the input is 1/s^2.

Solution:

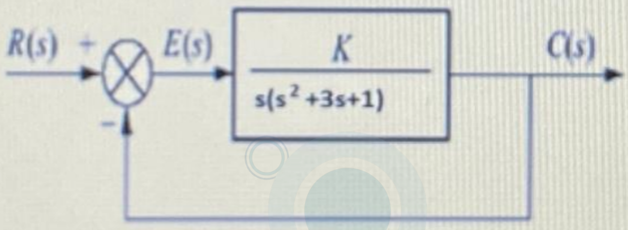
ramp input finite when N = 1

$$K_v = \lim_{s\to 0} s\,\frac{1}{s+1}\,\frac{1}{s^2+4s+20}\,\frac{K}{s} = \frac{K}{20}$$

$$e = \frac{1}{K_v} \qquad 1 = \frac{1}{K/2} \qquad K = 20$$

Controller =............ $\boxed{\frac{20}{s}}$ ....

Q5) find the steady state error for R= 2 + 3t (5 points)



▶ Subject : ....

$R = \boxed{2} + 3t$ → ramp

step

$K_v = \lim\limits_{s \to 0} \dfrac{\cancel{s}\,K}{\cancel{s}(s^2+3s+1)} = \boxed{K}$

$K_p = \lim\limits_{s \to 0} \dfrac{K}{s(s^2+3s+1)} = \infty$

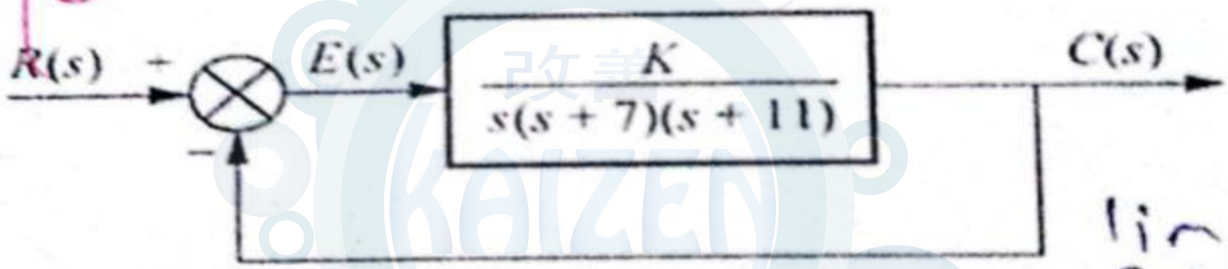
$e = \dfrac{3}{K_v} = \dfrac{3}{K}$

$e = \dfrac{1}{1+K_p} * 2 = 0$

$\text{error} = \dfrac{3}{K}$

6/6

Q4) Find the steady state error for a step input (5 points)



$\lim_{s \to 0} s$

$\boxed{\text{Step}}$

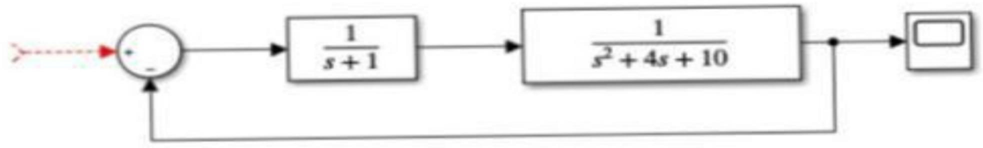
$$K_p = \lim_{s \to 0} \frac{K}{s(s+7)(s+11)} = \infty$$

$$e = \frac{1}{1+K_p} \quad \frac{1}{1+\infty} = 0$$

OR we can simply say

$N = 1 \rightarrow$ zero error for step

Q2 a) (5 points) Find the steady state error to a step input the following



Solution

Step input

$$K_p = \lim_{s \to 0} \frac{1}{s+1} \cdot \frac{1}{s^2+4s+10} = \frac{1}{10}$$

$$e = \frac{1}{1+\frac{1}{10}} = \frac{10}{11} \simeq 0.91$$

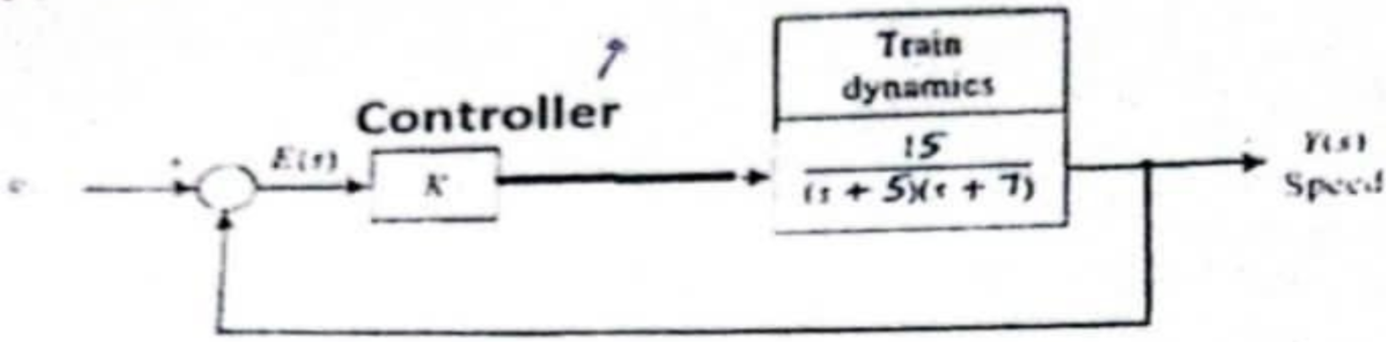
Step input

$$K_p = \lim_{s \to 0} \frac{100 * 10}{s(s+5)} = \infty$$

$$e_{ss} = \frac{5}{1+\infty} = 0$$

or we can say N = 0, step so e = 0

Q3) For the following system



a)Find the steady state error to a step input (3.5)

7.5

$\left[\frac{15K}{\quad}\right] - \left|\frac{3}{7}K\right|$

step input

$$K_p = \lim_{s \to 0} \frac{15K}{(s+5)(s+7)} = \frac{\overset{3}{\cancel{15}}K}{\cancel{5} * 7}$$

$$\frac{1}{1+\frac{3K}{7}} = \frac{7}{7+3K}$$

My courses / INDUSTRIAL CONTROL SYSTEMS / General / Root locus routh hurw

$$G(s) = \frac{(s+z_1)(s+z_2)}{s^n(s+p_1)(s+p_2)}$$

if G is the open loop function and unity feedback is used

if n=1; and input A=1/s input B=1/s^2 input C= 1/s^3

then for which functions the steady state is finit (constant) not equal to zero

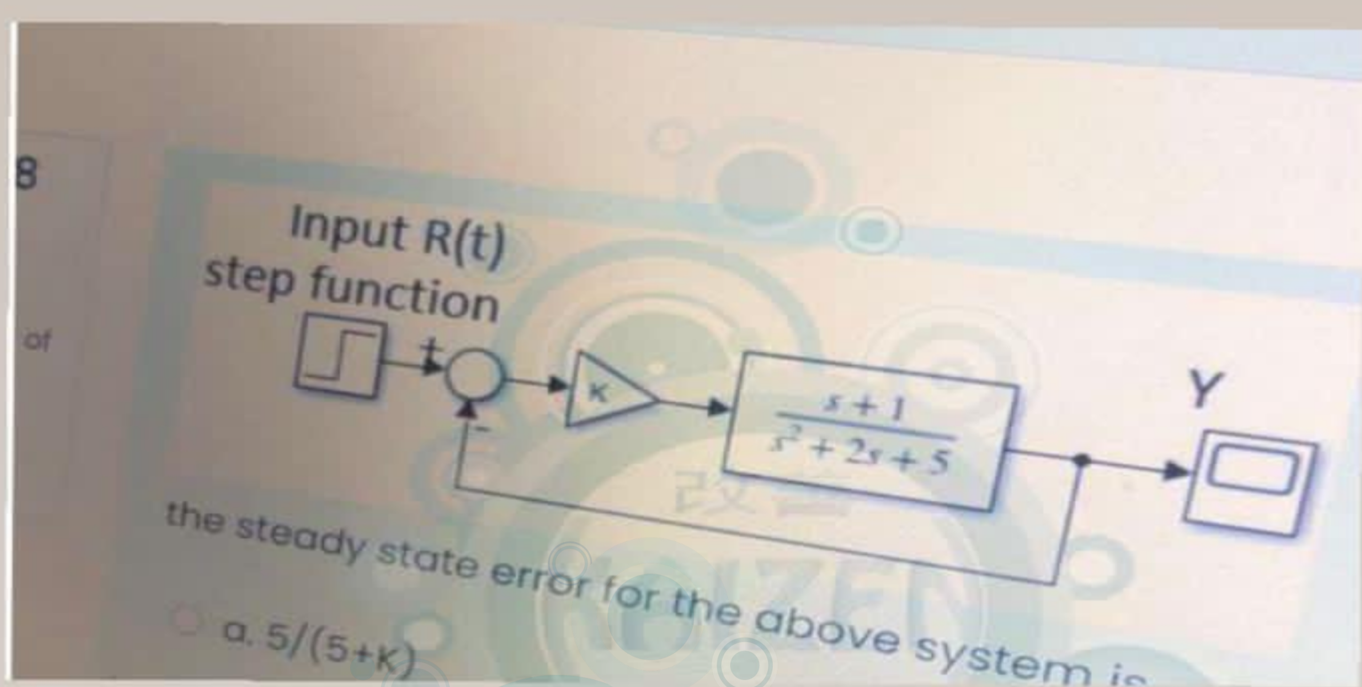
N=1

finite

for

$\frac{1}{s^2}$

So input B

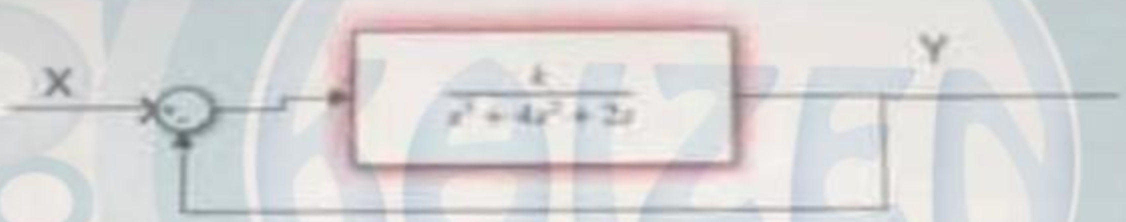


step input

$$K_p = \lim_{s \to 0} \frac{K(s+1)}{s^2+2s+5} = \frac{K}{5}$$

$$e = \frac{1}{1+\frac{K}{5}} = \frac{5}{5+K}$$

Time left 0:03



the steady state error to a ramp (1/s^2) input is

ramp

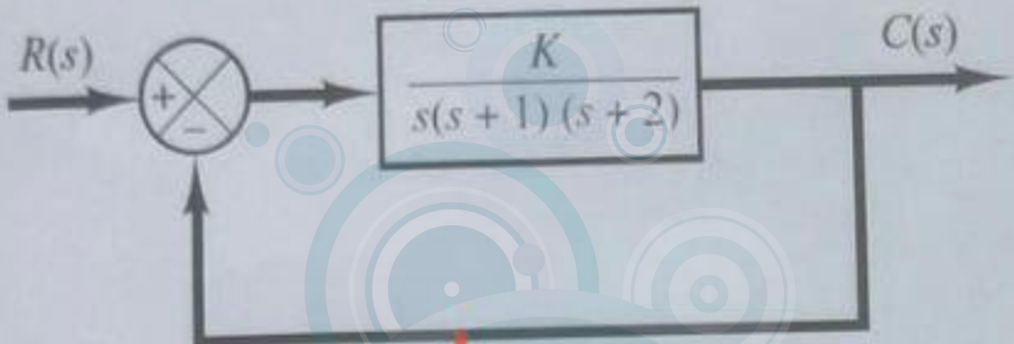
$$K_v = \lim_{s \to 0} \cancel{s} \, \frac{K}{\cancel{s}(s^2+4s+2)} = \frac{K}{2}$$

$$e = \frac{1}{K/2} = \frac{2}{K}$$

Quiz 4 Industrial control systems Prof. M. Barghash IE dept SoC UoJ 13/11/2024

Name ID:

For following system what is the steady state error for R= 3u(t) +5t



$3u(t) + 5t$

step ramp

$$K_p = \lim_{s \to 0} \frac{K}{s(s+1)(s+2)} = \infty$$

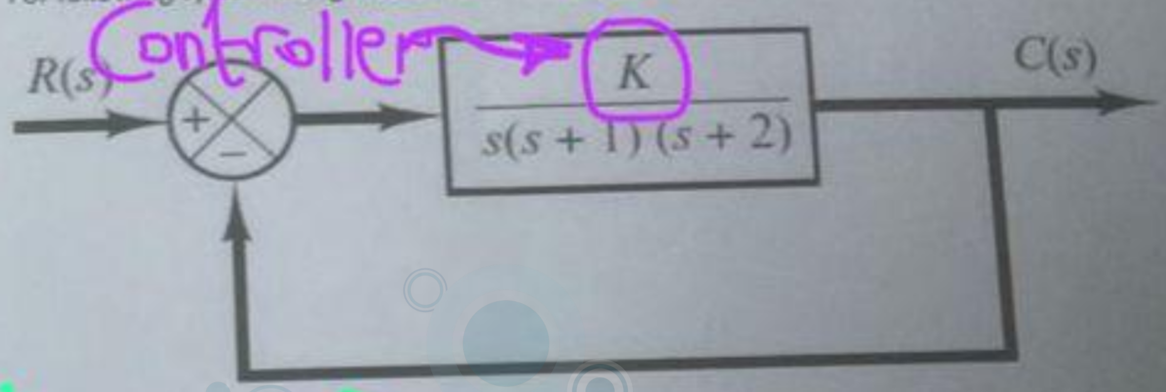
$$K_v = \lim_{s \to 0} \frac{\cancel{s}K}{(s+1)(s+2)\cancel{s}} = \frac{K}{2}$$

$$e = \frac{3}{1+\infty} + \frac{5}{K/2} = \boxed{\frac{10}{K}}$$

Quiz 4 Industrial control systems Prof. M. Barghash IE dept SoC UoJ 13/11/2024

Name ID:

For following system design k to achieve 0.1 steady state error for a ramp input



ramp input finite when N = 1 which is our case so the controller is K

$$K_v = \lim_{s \to 0} \frac{\cancel{s}\, K}{\cancel{s}(s+1)(s+2)} = \frac{K}{2}$$

$$\frac{1}{\frac{K}{2}} = \frac{1}{10}$$

$$K/2 = 10$$

$$\boxed{K = 20}$$

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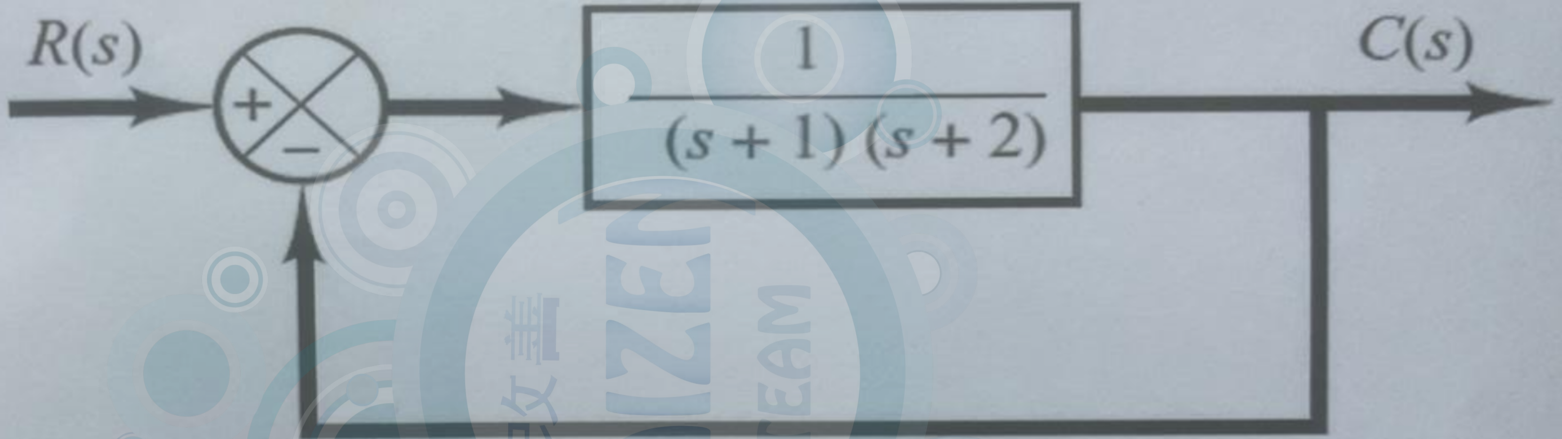
Name ID:

For following system add a controller to achieve 0.1 steady state error for a step input



Step input finite when $N=0$

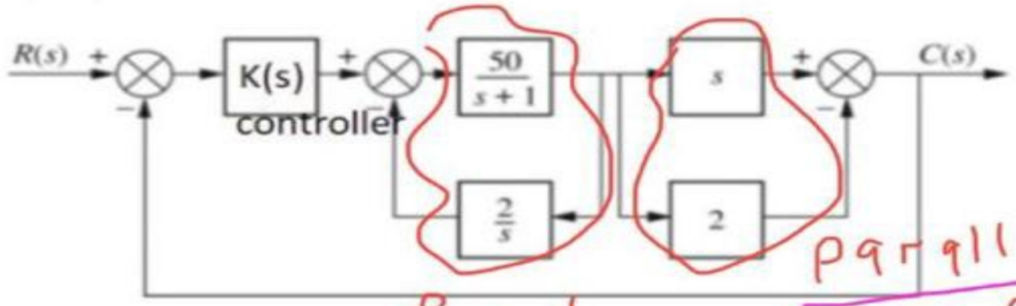
$$K_p = \lim_{s \to 0} k \frac{1}{(s+1)(s+2)} = \boxed{\frac{k}{2}}$$

$$\frac{1}{1 + k/2} = 0.1$$

$$1 + k/2 = 10$$

$$\boxed{k = 18}$$

Q2)for the following system design the steady state error for a step input to be zero and for a ramp input to be less than 2 (design the controller)? (note K(s) is any function of s to be suitably designed) (10 points)



parallel

$s-2$

feed back

$$\frac{\frac{50}{s+1}}{1+\frac{50}{s+1}\,\frac{2}{s}} = \frac{50s}{s^2+s+100}$$

series

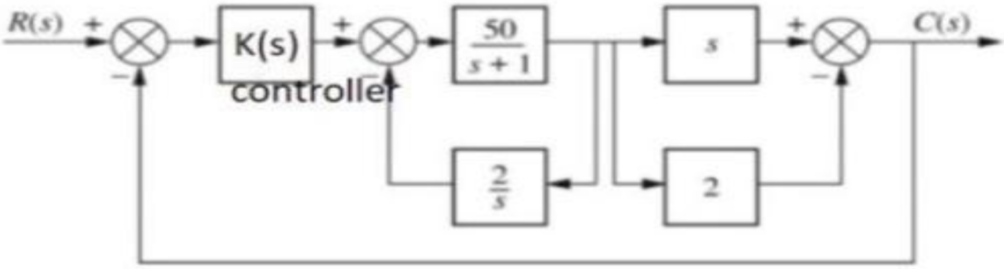
$$G(s) = \frac{50s(s-2)}{s^2+s+100}$$

a) a step to be zero when $N \geq 1$ $K \neq 0$

So $K(s) = \frac{K}{s^2}$ as there is an 'S' in the Numerator

(1)

Q2)for the following system design the steady state error for a step input to be zero and for a ramp input to be less than 2 (design the controller)? (note K(s) is any function of s to be suitably designed) (10 points)



$$G(s) = \frac{50\,s(s-2)}{s^2+s+100}$$

for a ramp to be less than $\boxed{2}$

Case 1

$e = 0$

when $N \geq 2$

So $K(s) = \frac{K}{s^3}$

$K \neq 0$

as there is an 's' in the Numerator

Case 2

e finite and ≤ 2

when $N = 1$

$K_v = \lim_{s \to 0} \cancel{s}\, \frac{50\,\cancel{s}(s-2)}{s^2+s+100} \cdot \frac{K}{\cancel{s}^2}$

Controller

$= -K$

$\frac{1}{-K} \leq 2$

$-K \geq \frac{1}{2}$

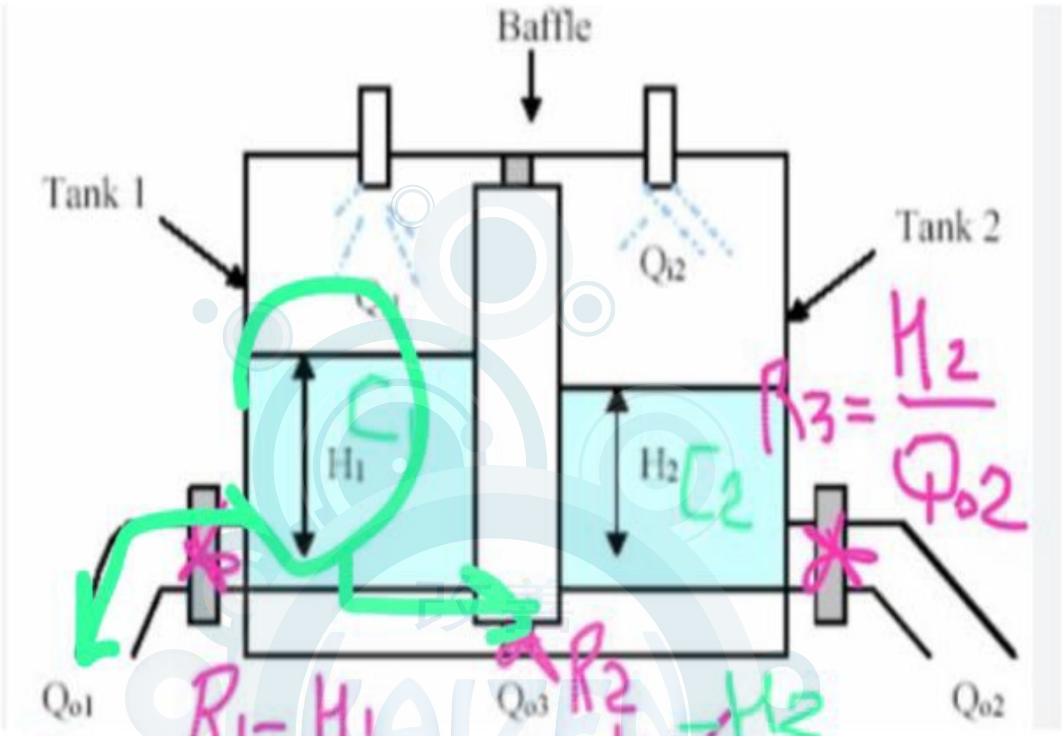
(2) $\boxed{K \leq -\frac{1}{2}}$?

Prof M. Barghash IE dept UoJ The university of Jordan Quiz 4

Name ID

Answer the following question

Q1) write the differential equations describing the level system



$R_3 = \frac{H_2}{Q_{o2}}$

$R_1 = \frac{H_1}{Q_{01}}$ $R_2 = \frac{H_1 - H_2}{Q_{o3}}$

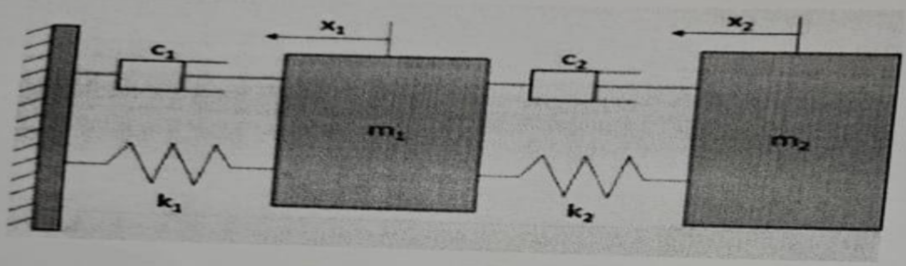
Tank1

$$Q_{i1} - Q_{o1} - Q_{o3} = C_1 \frac{dh_1}{dt}$$

Tank2

$$Q_{i2} + Q_{o3} - Q_{o2} = C_2 \frac{dh_2}{dt}$$

Write the equations describing the model



$\frac{1}{c_1 s}$, k_1 , $\frac{1}{c_2 s}$, k_2

$x_1 = \frac{1}{c_1 s} \frac{c_1 s}{k_1} + m_1$

$x_2 = \frac{k_2}{c_2 s} + m_2$

$+c$ $\frac{}{Qs}$

Node $\boxed{1}$

$$0 = m_1 \ddot{x}_1 + c_1 \dot{x}_1 + k_1 x_1 + c_2(\dot{x}_1 - \dot{x}_2) + k_2(x_1 - x_2)$$

Node $\boxed{2}$

$$0 = m_2 \ddot{x}_2 + c_2(\dot{x}_2 - \dot{x}_1) + k_2(x_2 - x_1)$$

$0 = m_1 \ddot{x}_1 + k_1(x_1 - x_2)$

Second Cart (TMD)

$$0 = m_2 \ddot{x}_2 + k_1(x_2 - x_1) + b\dot{x}_2 + k_2 x_2$$

Tank ①

$$q_1 - q_2 = C_1 \frac{dh_1}{dt}$$

$$R_1 = \frac{H_1 - H_2}{Q_2}$$

Tank ②

$$q_2 - q_s = C_2 \frac{dh_2}{dt}$$

$$R_2 = \frac{H_2}{Q_s}$$

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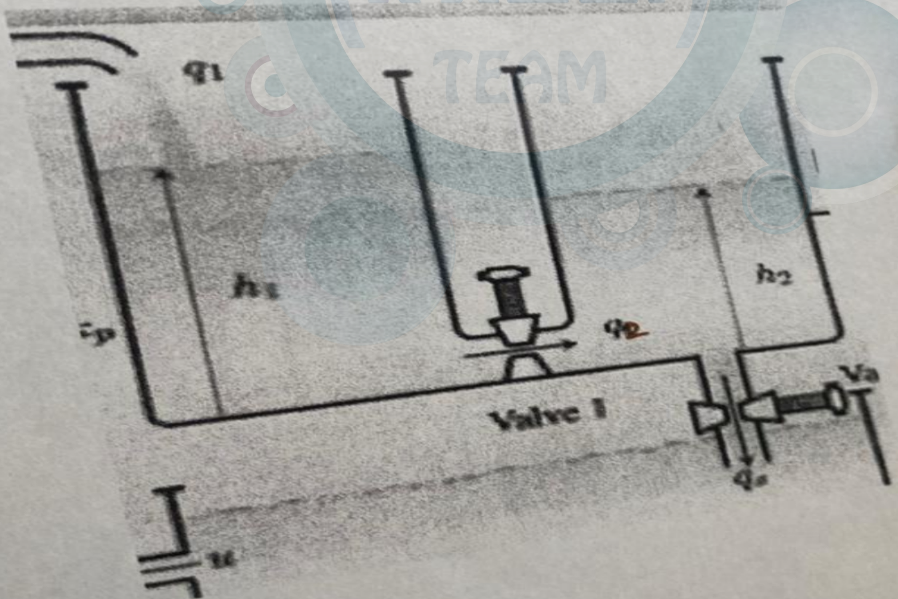
Name: ID:

Q) Write the equations describing the following system add needed symbols



$q_1 h_1 =$

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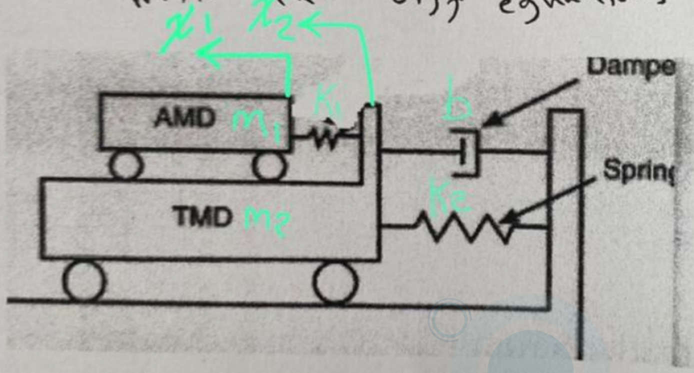
Name: ID:

write the diff equations ?



first Cart (AMD)

$$0 = m_1 \ddot{x}_1 + k_1 (x_1 - x_2)$$

Second Cart (TMD)

$$0 = m_2 \ddot{x}_2 + k_1 (x_2 - x_1) + b \dot{x}_2 + k x_2$$

Control Q

Control slides

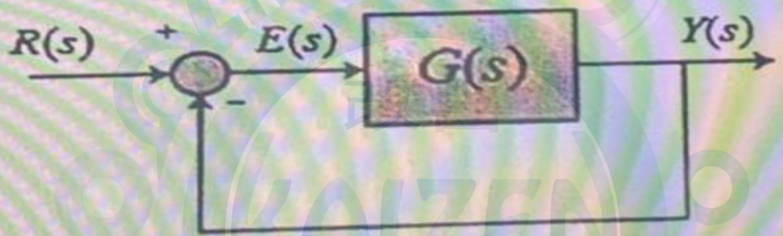
Quiz industrial control systems IE dept SoC UoJ Prof. M. Barghash 21/11/2024

Name ID

step ramp

Q1) find the steady state error for R=(4+3t)u(t)

$$G(s) = \frac{K(s+1)}{s(s+5)(s+7)}$$



$$\lim \frac{K(s+1)}{s(s+5)(s+7)} = \infty$$

$$\frac{4}{1+\infty} = 0$$

$$\lim_{s\to 0} \frac{\cancel{s}\,K(s+1)}{\cancel{s}(s+5)(s+7)}$$

$$= \frac{K \times 3}{35}$$

$$\frac{35}{3K}$$

التاريخ : .... الموضوع : ....

Step

$$K_p = \lim_{S \to 0} \frac{K(S+1)}{S(S+5)(S+7)} = \infty$$

ramp

$$K_V = \lim_{S \to 0} \frac{\cancel{S}\, K(S+1)}{\cancel{S}(S+5)(S+7)} = \frac{K}{35}$$

$$e = \frac{4}{1+\infty} + \frac{3}{\frac{K}{35}}$$

$$= 0 + \frac{105}{K} = \boxed{\frac{105}{K}}$$

Step finite when $N=0$

$K \rightarrow$ Controller

$$K_p = \lim_{S \to 0} \frac{K(S+1)}{(S+5)(S+7)} = \frac{K}{35}$$

$$e = \frac{1}{1+\frac{K}{35}} < 0.1$$

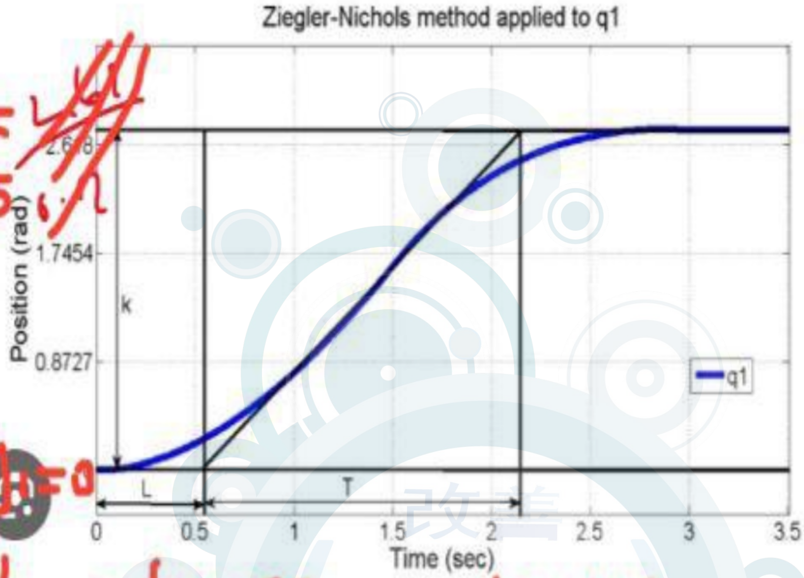
$$1+\frac{K}{35} > 10$$

$$\boxed{K > 315}$$

Quiz ... PID Prof M. Barghash Industrial control
UoJ Sch of Eng IE Depart

Name ID

$Y_\infty = \cancel{4}$ 2.75



$y_0 = 0$

$t_0 = 0$ $t_1 = 0.55$ $t_2 = 2.15$

$K_0 = \frac{2.75 - 0}{0.3 - 0.1} = 13.75$ rad/KW

$\tau_0 = 0.55$ s

$\nu_0 = 1.6$ s

The response when we changes the input from 0.1 to 0.3 KW the output changed according to the figure

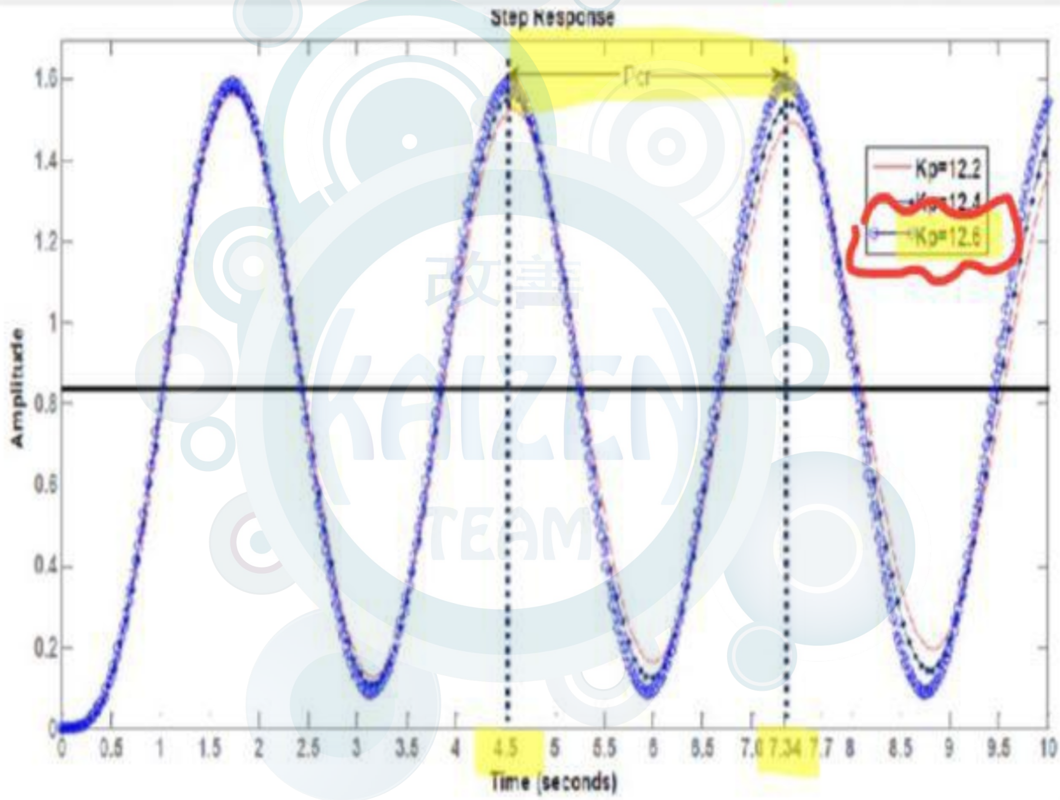
	K_p	T_r	T_d
P	$\frac{\nu_o}{K_o \tau_o}$ 0.212	–	–
PI	$\frac{0.9\nu_o}{K_o \tau_o}$ 0.190	$3\tau_o$ 1.65	–
PID	$\frac{1.2\nu_o}{K_o \tau_o}$ 0.254	$2\tau_o$ 1.1	$0.5\tau_o$ 0.275

Quiz Industrial control UoJ IE M. Barghash

Name ID

Q) Tune the PID controller using the zeigler nichols oscillation technique

Type of Controller	K_p	T_i	T_d
P	$0.5K_{cr}$	∞	0
PI	$0.45K_{cr}$	$\frac{1}{1.2}P_{cr}$	0
PID	$0.6K_{cr}$ 7.56	$0.5P_{cr}$ 1.42	$0.125P_{cr}$ 0.355



P= 2.84 s

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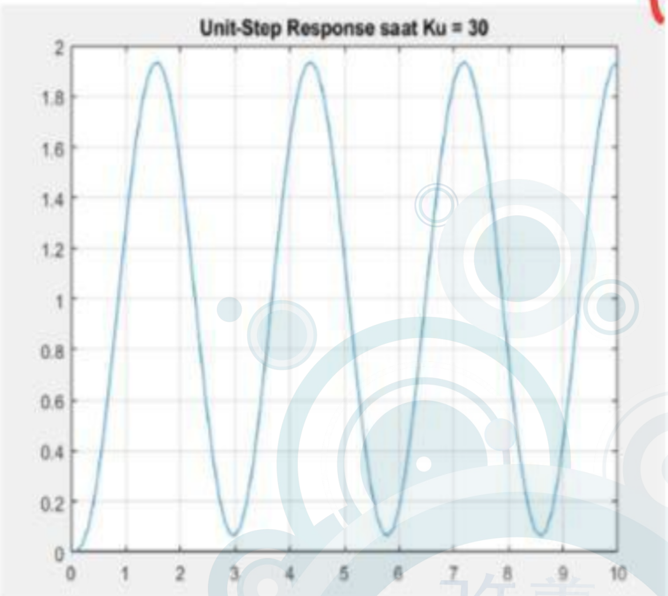
Name ID

Q) Tune the PID controller using the zeigler nichols oscillation technique



$P = 10/3.5$

$= 2.86\,s$

$K = 30$

The response above is obtained for the system for the PID auto tuning Ziegler Nichols oscillation method. What is the PID controller

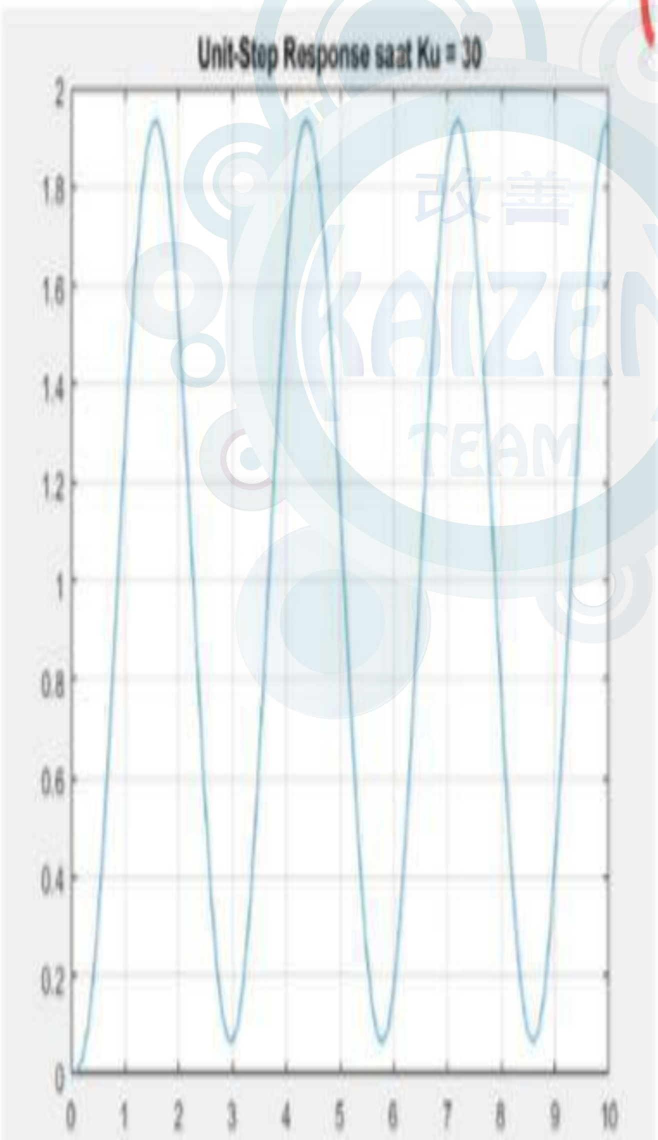
Type of Controller	K_p	T_i	T_d
P	$0.5K_{cr}$	∞	0
PI	$0.45K_{cr}$	$\frac{1}{1.2}P_{cr}$	0
PID	$0.6K_{cr}$	$0.5P_{cr}$	$0.125P_{cr}$

18 1.43 0.3575

Quiz Industrial control UoJ IE M. Barghash

Name ID

Q) Tune the PID controller using the zeigler nichols oscillation technique



$P = 10/3.5$

$= 2.86s$

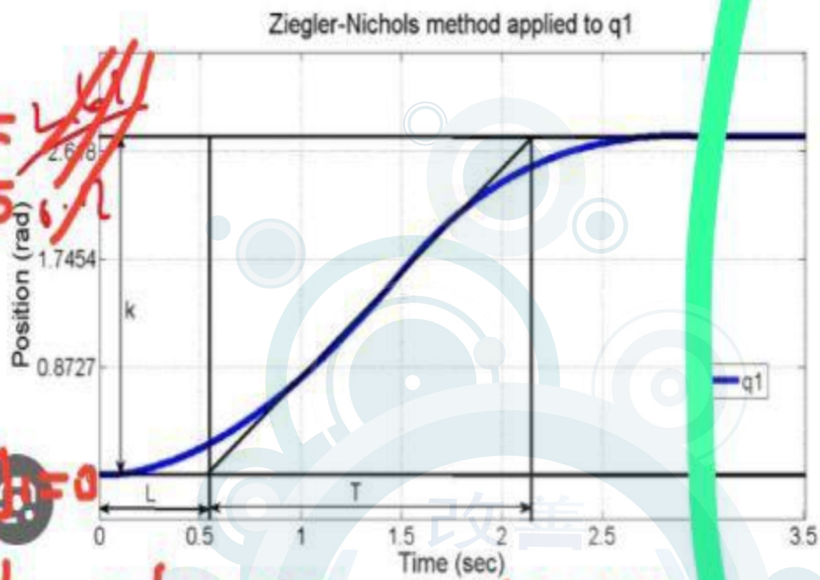
$K = 30$

Quiz ... PID Prof M. Barghash Industrial Control

UoJ Sch of Eng IE Depart

Name ID

$y_\infty = 2.75$



$y_0 = 0$

$t_0 = 0$ $t_1 = 0.55$ $t_2 = 2.15$

$$K_o = \frac{2.75 - 0}{0.3 - 0.1} = 13.75 \text{ rad/KW}$$

$\tau_o = 0.55\,s$

$\nu_o = 1.6\,s$

The response when we changes the input from 0.1 to 0.3 KW the output changed according to the figure

	K_p	T_r	T_d
P	$\frac{\nu_o}{K_o\tau_o}$ 0.212	–	–
PI	$\frac{0.9\nu_o}{K_o\tau_o}$ 0.190	$3\tau_o$ 1.65	–
PID	$\frac{1.2\nu_o}{K_o\tau_o}$ 0.254	$2\tau_o$ 1.1	$0.5\tau_o$ 0.275

Flag question

$$s^4 + 3s^3 + 3s^2 + 2s^{\cancel{4}} + K$$

what is the value for K for stability

negative

>0

S_0

S^4	3	3	K
S^3	3	0	0
S^2	3	K	0
S^1	$-K$	0	0
S^0	K	0	0

$-K > 0$

$\boxed{K < 0}$

$\boxed{K > 0}$

won't be stable!

if Q was wrong Correc

$s^4 + 3s^3 + 3s^2 + 2s + K$

S^4	1	3	K
S^3	3	2	0
S^2	$7/3$	K	0
S^1	$\frac{14-9K}{7}$	0	0
S^0	K	0	0

$\boxed{K > 0}$

$14 - 9K > 0$

$14 > 9K$

$\boxed{K < 14/9}$

$\boxed{0 < K < 14/9}$

$$s^3 + s^2 + 2s + K = 0$$

what is the value for K for stability

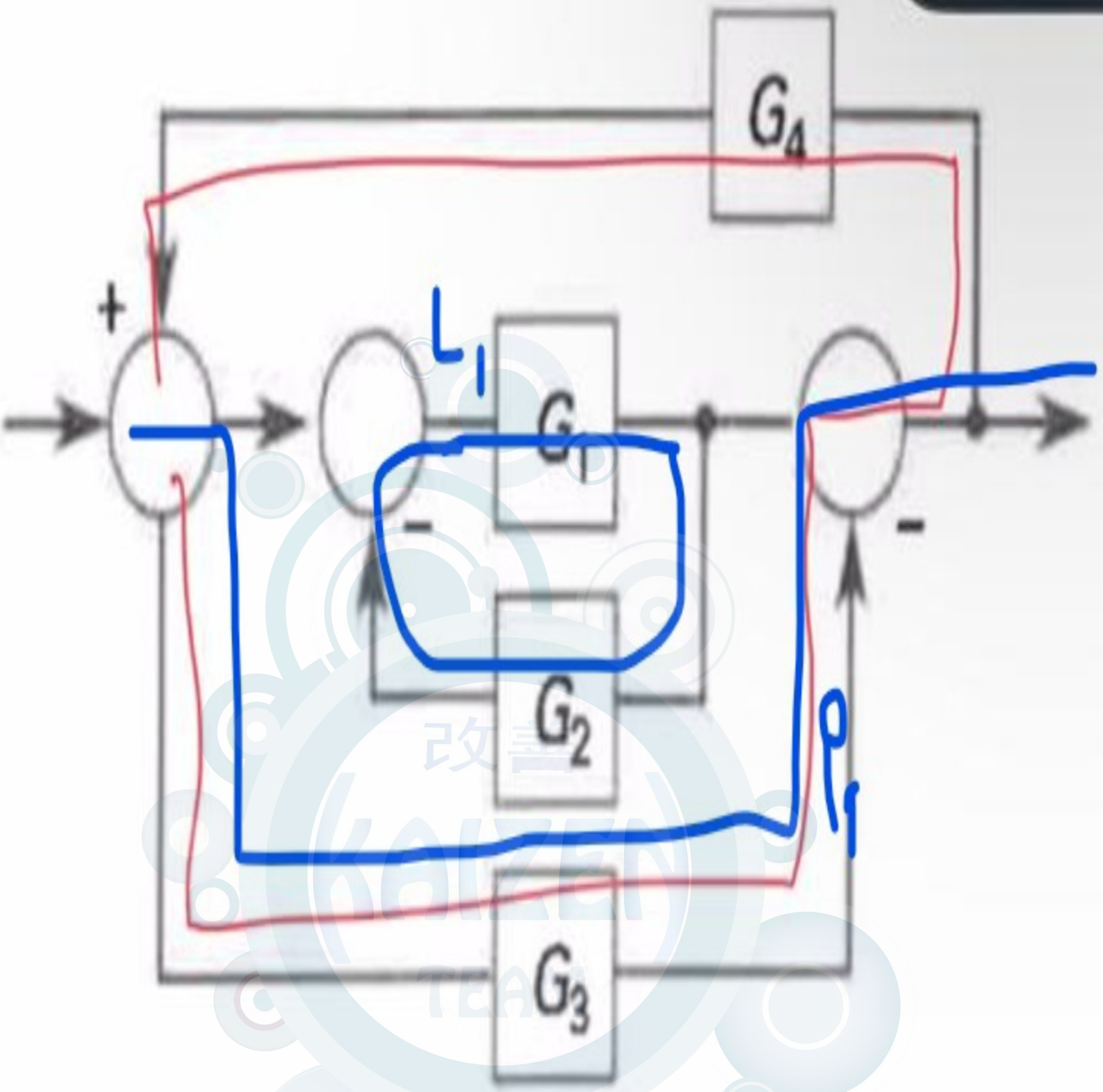
S^3	1	2	0
S^2	1	K	0
S^1	2-K	0	0
S^0	K	0	0

$2 - K > 0$ $\qquad$ $K > 0$

$2 > K$

$2 > K > 0$

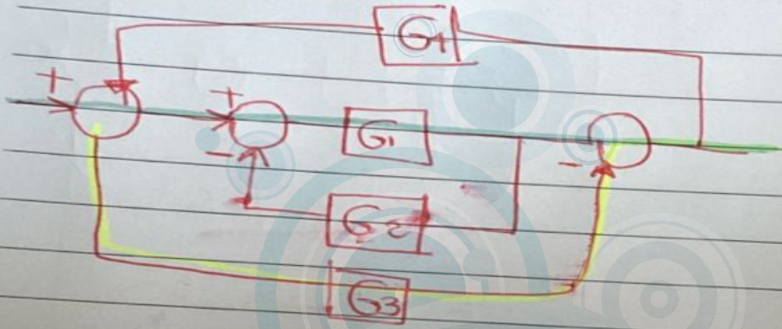
equivalent transfer function for



$$\frac{G_1 - G_3}{1 - (-G_1G_2 + G_1G_4 - G_3G_4) + (G_1G_2G_3G_4)}$$

التاريخ :

الموضوع :



paths

$\boxed{1}$ G_1 $\quad \Delta_1 = 1$

$\boxed{2}$ $-G_3$ → if we removed the path we wold still have the loop $-G_1G_2$ $\quad \Delta_2 = 1 + G_1G_2$

loops

① $+G_1G_4$

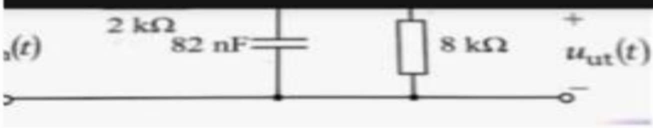
② $-G_1G_2$

③ $\bar{+}G_3G_4$

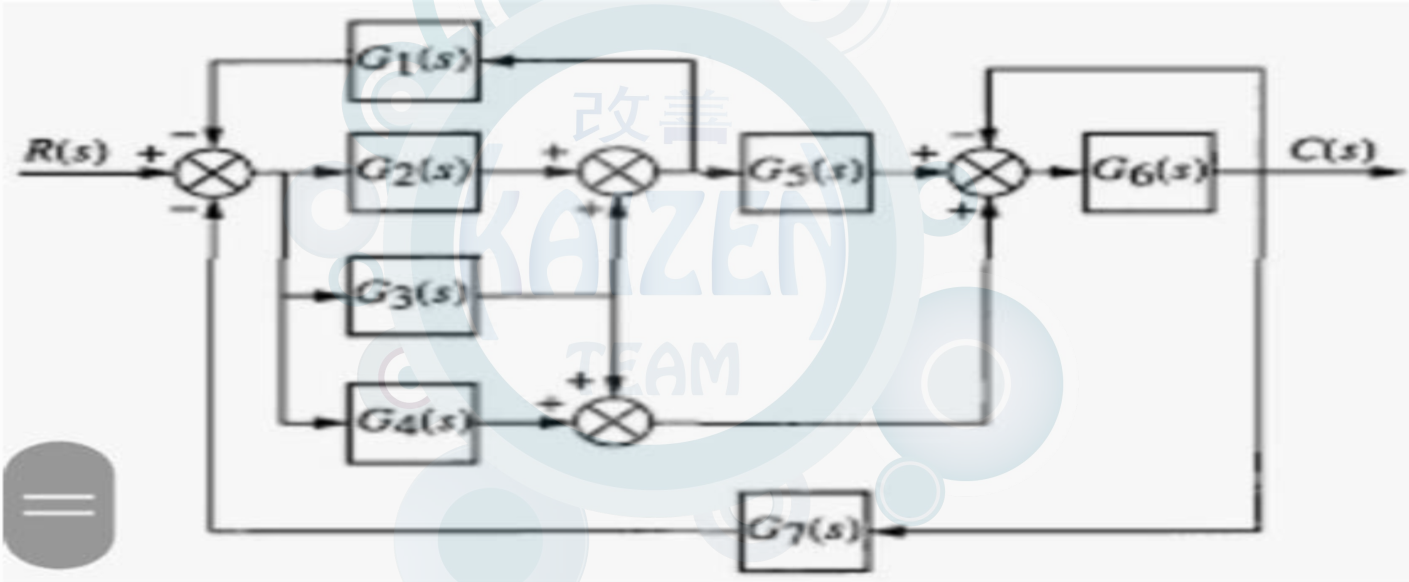
Nontouching

②/③ $G_1G_2G_3G_4$

$$\frac{G_1 - G_3(1+G_1G_2)}{1 - G_1G_4 + G_1G_2 + G_3G_4 + G_1G_2G_3G_4}$$



Find the equivalent transfer function for (5 points)



Subject :

paths:-

$\boxed{1}$ $G_2 G_5 G_6$ $\Delta_1 = 1$

$\boxed{2}$ $G_3 G_5 G_6$ $\Delta_2 = 1$

$\boxed{3}$ $G_4 G_6$ $\Delta_3 = 1$

$\boxed{4}$ $G_3 G_6$ $\Delta_4 = 1$

$$C(S)/R(S) = \frac{G_2G_5G_6 + G_3G_5G_6 + G_4G_6 + G_3G_6}{1 + G_1G_2 + G_6 + G_2G_5G_6G_7 + G_3G_5G_6G_7 + G_4G_6G_7 + G_3G_6G_7 + G_1G_2G_6}$$

loops:-

$\boxed{1}$ $-G_2G_1$

$\boxed{2}$ $-G_6$

$\boxed{3}$ $-G_2G_5G_6G_7$

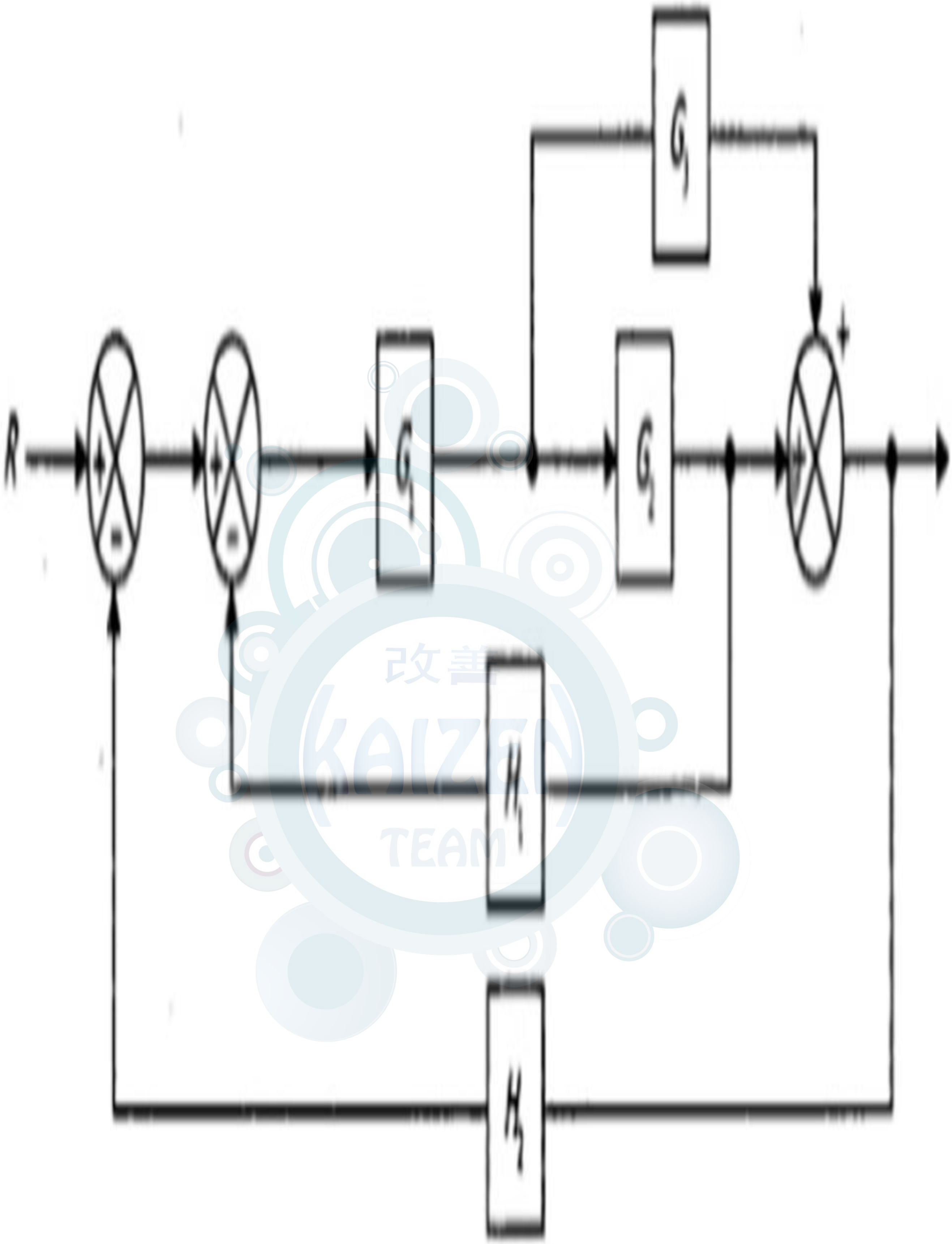
$\boxed{4}$ $-G_3G_5G_6G_7$

$\boxed{5}$ $-G_4G_6G_7$

$\boxed{6}$ $-G_3G_6G_7$

non touching loops

$\boxed{1}/\boxed{2}$ $G_1G_2G_6$


R
C

loop

paths	loops
$\boxed{1}$ G_1G_2	$\boxed{1}$ $-G_1G_2H_1$
$\boxed{2}$ G_1G_3	$\boxed{2}$ $-G_1G_2H_2$
	$\boxed{3}$ $-G_1G_3H_2$

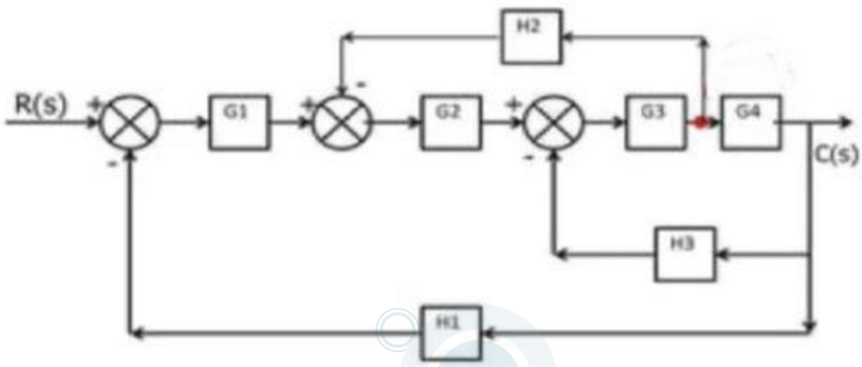
$\Delta_1 = 1$

$\Delta_2 = 1$

No non touching loops

$$\frac{G_1G_2 + G_1G_3}{1 + G_1G_2H_1 + G_1G_2H_2 + G_1G_3H_2}$$

Q4)Find the equivalent transfer function for (5 points)



Paths

P_1: $G_1G_2G_3G_4$

loops

1 $-G_2G_3H_2$

2 $-G_1G_2G_3G_4H_1$

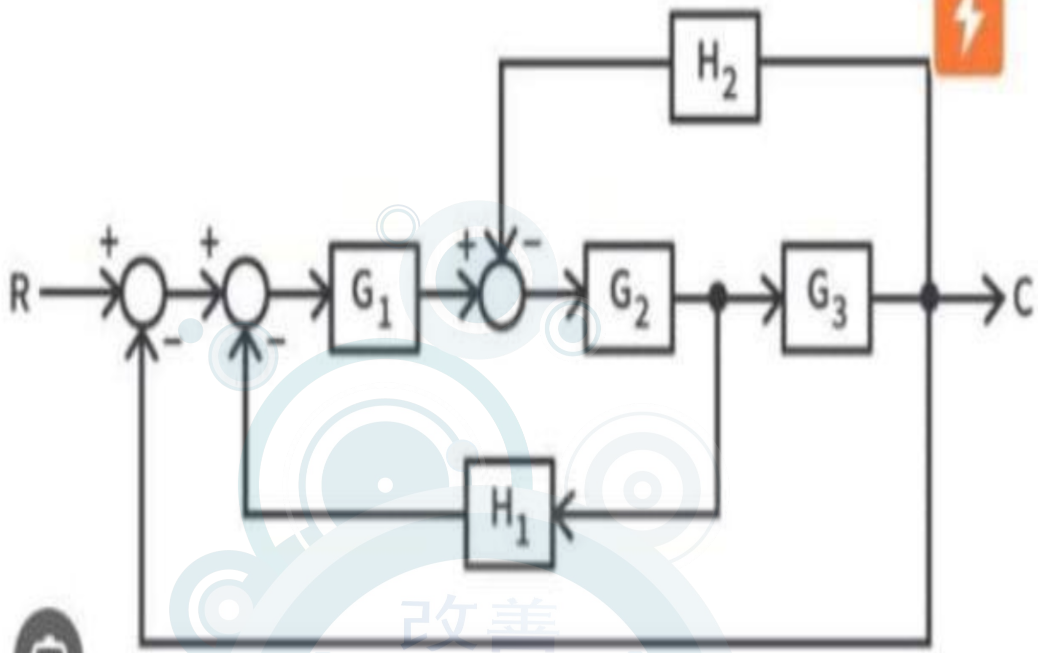
3 $-G_3G_4H_3$

$$\frac{C}{R} = \frac{G_1G_2G_3G_4}{1+G_2G_3H_2+G_1G_2G_3G_4H_1+G_3G_4H_3}$$

Quiz Industrial control systems Prof M. Barghash IE dept Sch o Eng UoJ 23/7/2024

Name: ID:

Find the equivalent transfer function



Paths:

P_1: $G_1G_2G_3$

loops:

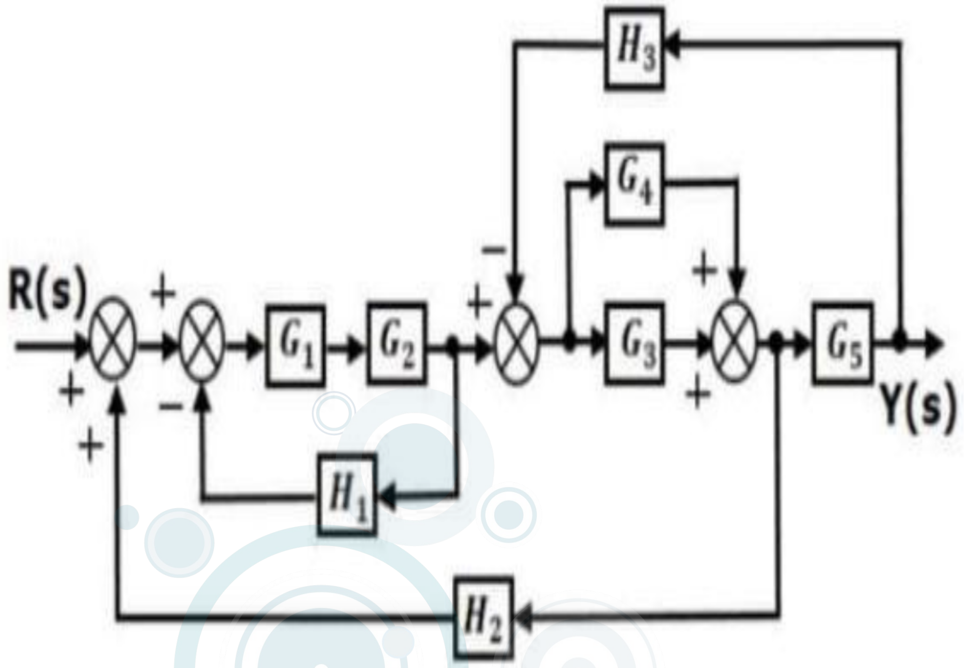
$\boxed{1}$ $-G_1G_2H_1$

$\boxed{2}$ $-G_1G_2G_3$

$\boxed{3}$ $-G_2G_3H_2$

$$C/R = \frac{G_1G_2G_3}{1+G_1G_2H_1+G_1G_2G_3+G_2G_3H_2}$$

Find the equivalent transfer function



paths

P_1: $G_1G_2G_3G_5$

P_2: $G_1G_2G_4G_5$

loops:

$\boxed{1}$ $-G_1G_2H_1$

$\boxed{2}$ $G_1G_2G_3H_2$

$\boxed{3}$ $-G_3G_5H_3$

$\boxed{4}$ $-G_4G_5H_3$

$\boxed{5}$ $G_1G_2G_4H_2$

Non touching loops

$\boxed{1}+\boxed{4}$ $G_1G_2G_4G_5H_1H_3$

$\boxed{1}+\boxed{3}$ $G_1G_2G_3G_5H_1H_3$

$$\frac{Y}{R} = \frac{G_1G_2G_3G_5 + G_1G_2G_4G_5}{1 + G_1G_2H_1 - G_1G_2G_3H_2 + G_3G_5H_3 + G_4G_5H_3 - G_1G_2G_4H_2 + G_1G_2G_4G_5H_1H_3 + G_1G_2G_3G_5H_1H_3}$$

```
Const int LED1=6;LED2=5;LED3=4;

Void setup()
{
  pinMode(LED1,OUTPUT);
  pinMode(LED2,OUTPUT);
  pinMode(LED3,OUTPUT);
}

Void loop()
{
  digitalWrite(LED1;HIGH);
  delay(100);
  digitalWrite(LED2;HIGH);
  delay(100);
  digitalWrite(LED3;HIGH);
}
```

Quiz Industrial control systems Prof. M. Barghash IE Dept SoC UoJ 7/1/2025

Name ID

Solve the following differential equation using ODE45 for t from 0 to 5

$$\dddot{W} + \ddot{W} + \dot{W} + 2W = \sin(t) \quad W(0) = 0 \quad \dot{W}(0) = 1 \quad \ddot{W}(0) = 2;$$

Quiz Industrial control systems Prof. M. Barghash IE Dept SoC UoJ 7/1/2025

Name ID

Solve the following differential equation using symbolic

$$\dddot{W} + \ddot{W} + \dot{W} + 2W = \sin(t) \quad W(0) = 0 \quad \dot{W}(0) = 1 \quad \ddot{W}(0) = 2;$$

ODE 45

$\omega_1, \omega_2, \omega_3$

$\omega_2 = \dot{\omega}_1 \sim (1)$

$\omega_3 = \dot{\omega}_2 \sim (2) = \ddot{\omega}_1$

$\dot{\omega}_3 + \omega_3 + \omega_2 + 2\omega_1 = \sin(t)$

$\dot{\omega}_3 = \sin(t) - \omega_3 - \omega_2 - 2\omega_1 \sim (3)$

```
function dw=qniz(t,w)
[m,n]=siz(w);
dw= zeros(m,n);
dw(1)= w(2);
dw(2)= w(3);
dw(3)= sin(t)-w(3)-w(2)-2*w(1);

tspan=[0 5];
w0= [0;1;2];
[t w]= ode45(@qniz,tspan,w0)
```

Symbolic

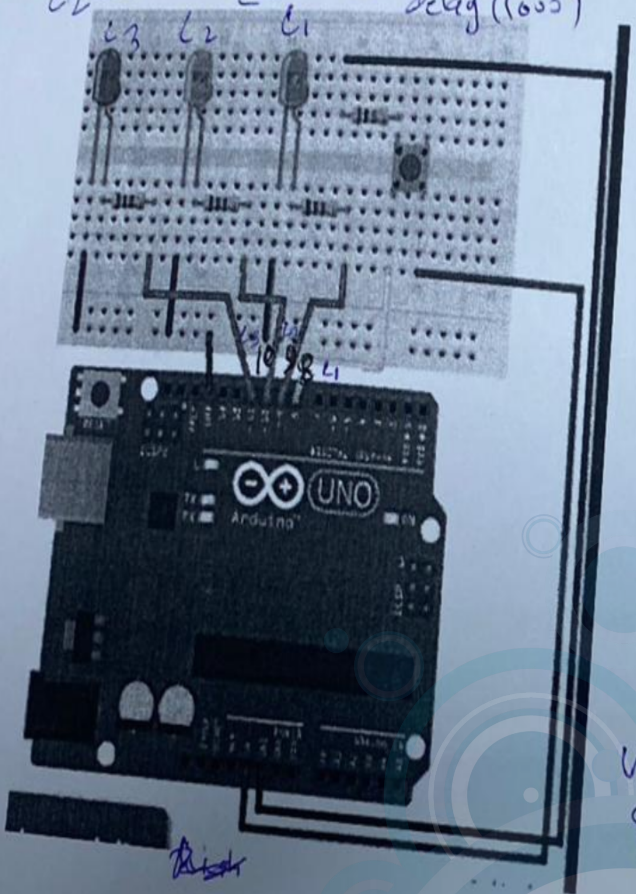
```
Syms w(t)
eqn= diff(w,t,3)+diff(w,t,2)+diff(w,t)
  +2*w == Sin(t);
dw = diff(w,t);
dw2 = diff(w,t,2);
Cond= [ w(0)==0, dw(0)==1, dw2(0)==2];
Sol=dsolve(eqn, Cond)
```

Arduino

```
Const int TPin= 0;
Void setup()
{Serial.begin(9600);}
Void loop()
{ double Voltage, Temperature;
Voltage= getvoltage(Tpin);
Temperature= (Voltage-0.5)100;
Serial.print("T is: ");
Serial.println(Temperature);
delay(1000);}
double getvoltage(int Tpin)
{ return (analogRead(TPin)*5/1024);}
```

For the following Arduino LED write the code for the lighting sequence right then middle then left then middle , separate each with 1 second delay

L2 ← ← delay(1000)




```
const int L1=8, L2=9, L3=10;
void setup()
{
pinMode(L1, OUTPUT);
pinMode(L2, OUTPUT);
pinMode(L3, OUTPUT);
}

void loop()
{
digitalwrite(L1, HIGH);
digital write (L2, LOW);
digital write (L3, LOW);
delay(1000);
digitalwrite(L1, LOW);
digital write (L2, HIGH);
digital write(L3, LOW);
delay(1000);
digital write(L1, LOW);
digital write
```

```
digital write(L1, LOW);
digital write(L2, HIGH);
digital write(L3, LOW);
delay(1000);
}
```

Solve the following differential equation using ODE45 $t=[0 \quad 5]$

$$\ddot{X} + 3X + 2t = 0 \quad X(0) = 0 \quad \dot{X}(0) = 1;$$

$\ddot{x} = -3x - 2t$

$\boxed{\dot{x}_2 = -3x_1 - 2t}$

$X = X_1$

$\dot{X}_1 = X_2$

$\ddot{X} = \dot{X}_2$

$\dot{X}_1 = \dot{x}_2$

```
function dx = quiz(t,x)
[m,n] = size(x);
dx = zeros(m,n).
dx(1) = x(2);
dx(2) = -3*x(1) - 2*t;
tspan = [0  5];
x0 = [0; 1];
[t,x] = ode45(@quiz, tspan, x0);
plot(t,x)
```

Quiz Industrial control systems

Name Prof. M. Barghash

ID IE Dept SoC UoJ 7/1/2025

Solve the following differential equation using symbolic

$$\ddot{X} + 3X + 2t = 0 \quad X(0) = 0 \quad \dot{X}(0) = 1;$$

```
syms x(t)
eqn = diff(x,t,2) + 3*x + 2*t == 0;
dx = diff(x,t);
cond = [x(0)==0, dx(0)==1];
S = dsolve(eqn, cond)
```

$$\ddot{x}+1=t \qquad x(0)=0 \qquad \dot{x}(0)=0$$

a)

x_1, x_2

$\dot{x}_1 = x_2 \sim (1)$

$\dot{x}_2 + 1 = t$

$\dot{x}_2 = t-1 \sim (2)$

```
function dx= quiz(t,x)
[m,n]= size(x);
x= zeros(m,n);
dx(1)= x(2);
dx(2)= t-1;
```

```
tspan= [0 10];
```
→ he should have gave us This

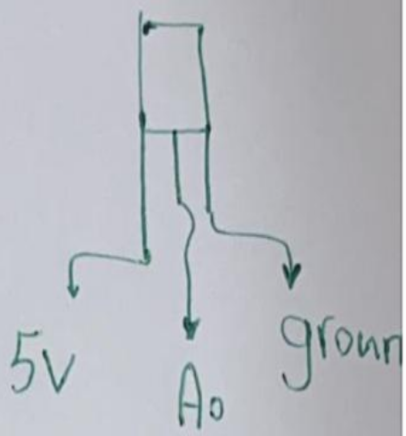
```
x0 = [0;0];
[t x]= ode45(@quiz, tspan, x0)
```

b)

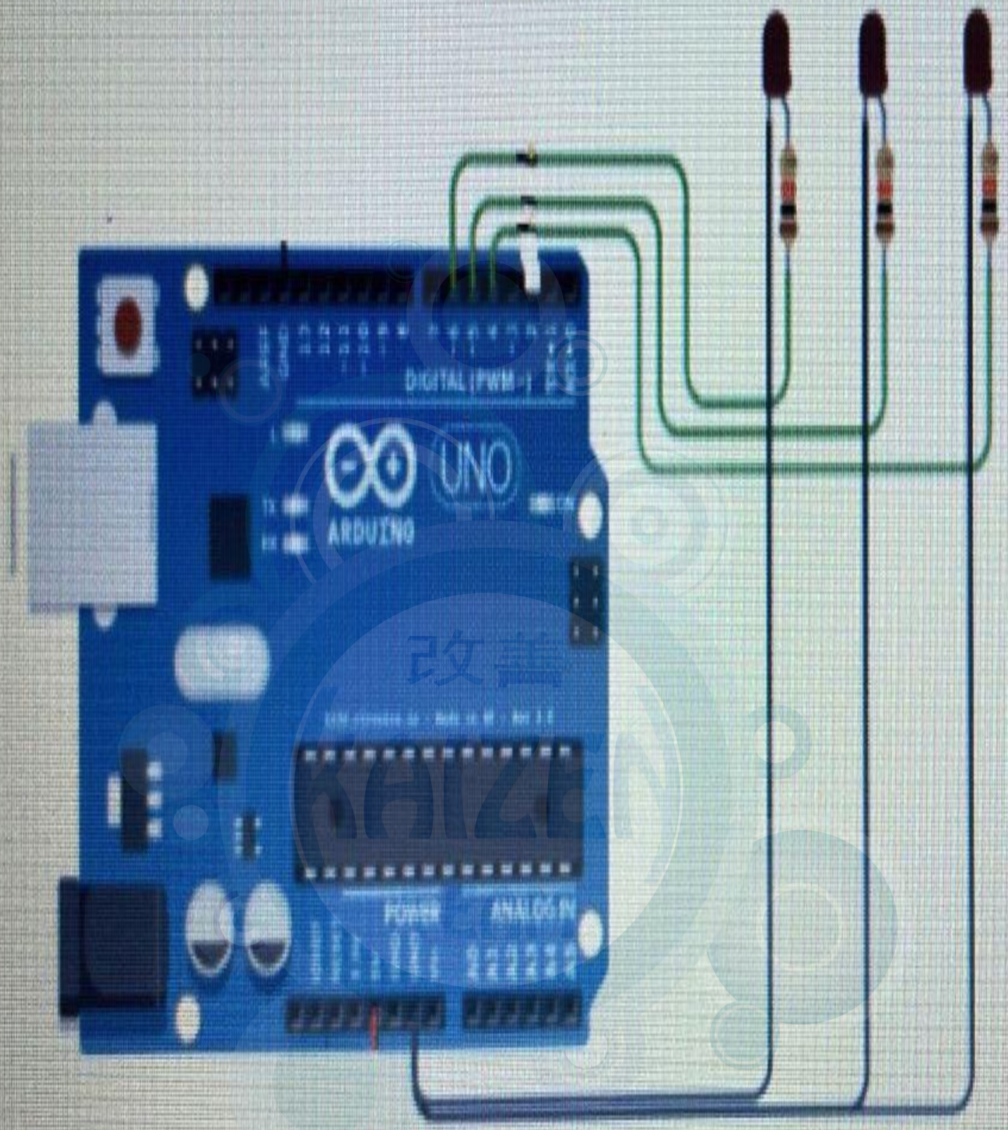
```
syms x(t)
eqn= diff(x,t,2)+1 == t;
dx=diff(x,t);
Cond = [x(0)==0, dx(0)==0];
Sol= dsolve(eqn,Cond);
```

```
Const int LED1=6, LED2=5, LED3=4;

Void setup()
{
  pinMode(LED1, OUTPUT);
  pinMode(LED2, OUTPUT);
  pinMode(LED3, OUTPUT);
}

Void loop()
{
  digitalWrite(LED1, HIGH);
  delay(100);
  digitalWrite(LED2; HIGH);
  delay(100);
  digitalWrite(LED3; HIGH);
}
```

```
Const int TPin=0;
Void setup()
{
Serial.begin(9600);
}

Void loop()
{

double voltage, Temperature;
Voltage=getvoltage(TPin);
Temperature=(Voltage-0.5)*100;
Serial.print("T is: ");
Serial.println(Temperature);
delay(1000);
}
double getVoltage(int Tpin)

{
Return (analogRead(TPin)*5/1024);
}
```



Q) Write the code for the light to start from left to right; separated by 0.1 seconds



Your Answer

a)wire the TMP36 to the Arduino (3 points)

b) Write suitable code to read the TMP36 signal, convert it to temperature then send the result to the computer screen.

Quiz Industrial control systems Prof M. Barghash IE dept Sch o Eng UoJ 23/7/2024

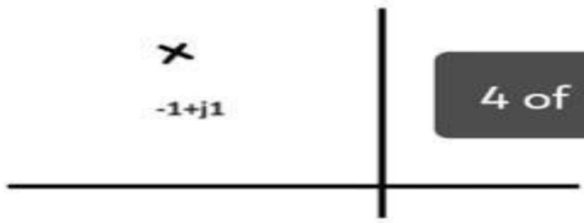
Name: ID:

For the following pole find the peak time

Quiz Industrial control systems Prof M. Barghash IE dept Sch o Eng UoJ 23/7/2024

Name: ID:

For the following pole find the percent overshoot



$\omega_n \xi = 1$

$\omega_n \sqrt{1-\xi^2} = 1$

$T_s = \dfrac{4}{\omega_n \xi} = 4\,s$

$P_o\% = \exp\left(\dfrac{-\pi \xi}{\sqrt{1-\xi^2}}\right) 100\%$

$= 4.32\%$

$T_p = \dfrac{\pi}{\omega_n \sqrt{1-\xi^2}} = 3.14\,s$

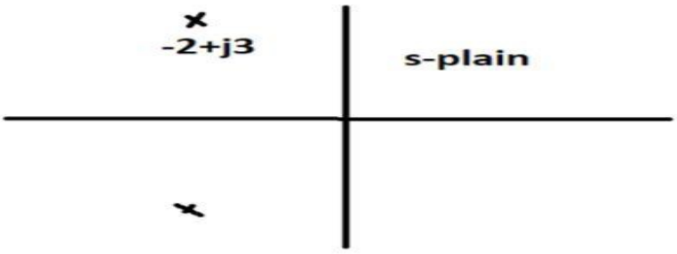
$T_r = 2.36\,s \longleftarrow$ extra

A L A D I B Notebook

QUIZ 3 INDUSTRIAL CONTROL PROF M BARGHASH IE DEPT UoJ 9/4/2023

NAME: ID:

For the following system with roots shown in the following s-plane find the rise time, settling time and percent overshoot



$\omega_n \zeta = 2$

$\omega_n \sqrt{1-\zeta^2} = 3$

$T_r = \dfrac{\pi - \theta}{\omega_n \sqrt{1-\zeta^2}}$

$= \dfrac{\pi - \tan^{-1}\left(\frac{3}{2}\right)\frac{\pi}{180}}{3}$

$= 0.7196\ s$

$T_s = \dfrac{4}{\omega_n \zeta} = \dfrac{4}{2} = 2$ seconds

$PO\% = \exp \dfrac{-\pi \zeta}{\sqrt{1-\zeta^2}} \times 100\%$

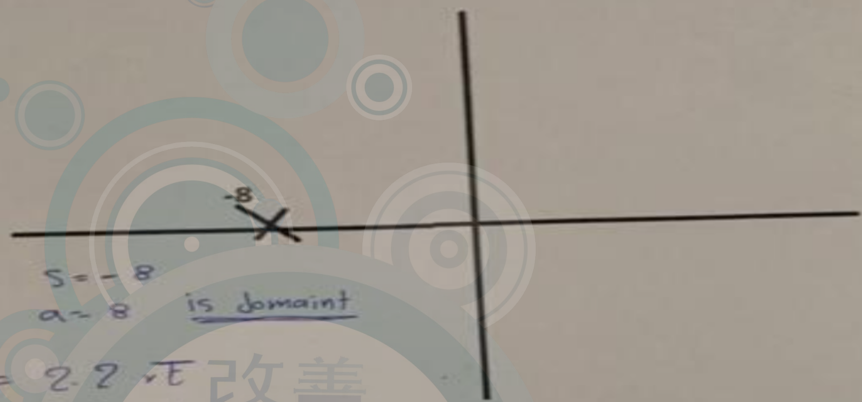
$= 12.31\%$

A L A D I B Not

Quiz 3 Industrial control systems Prof. M. Barghash IE dept SoC UoJ 10/11/2024

Name ID:

Find the rise time for the following dominant pole



$s = -8$

$a = 8$ is domaint

$T_r = 2.2\,\tau$

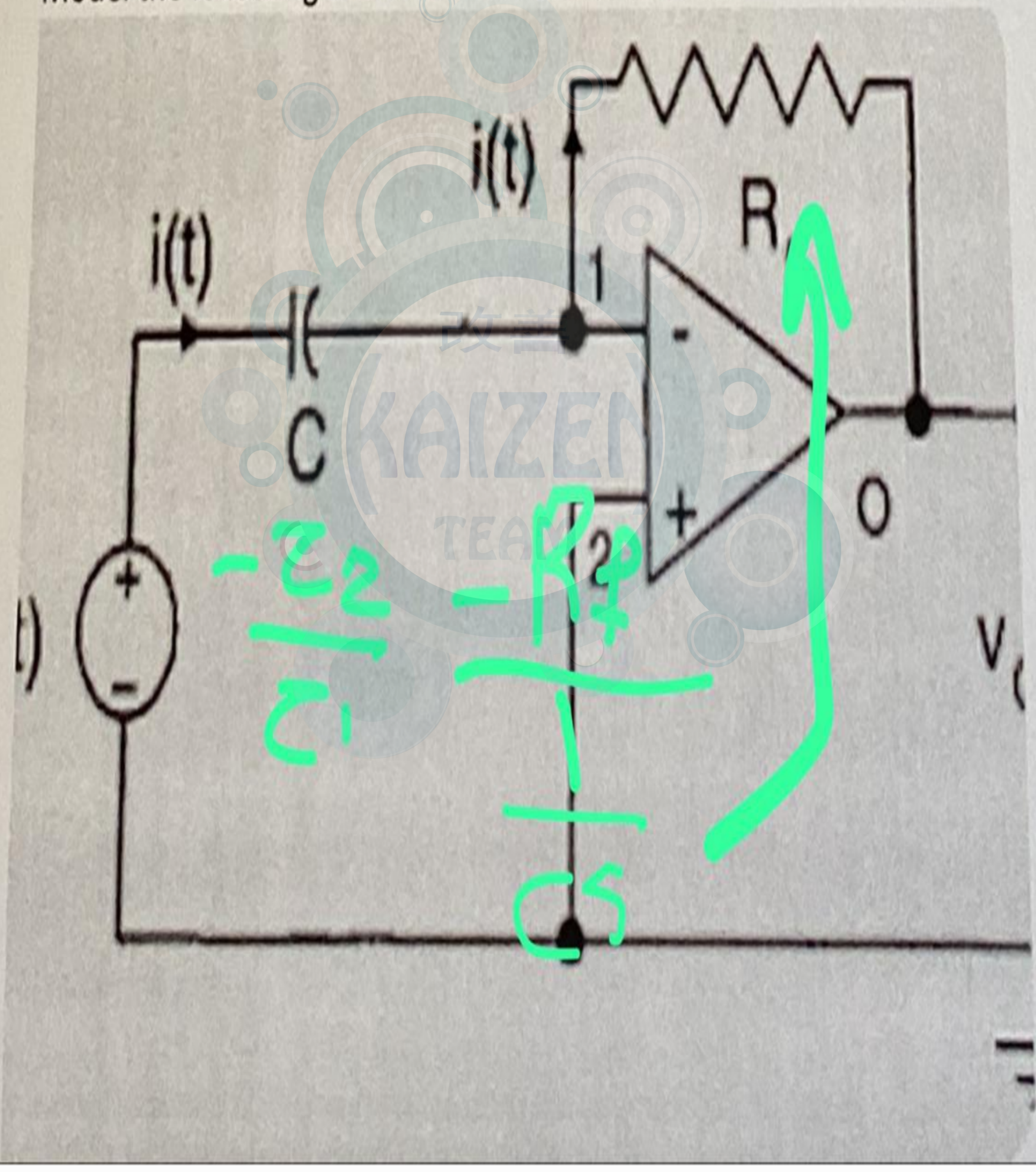
Your solution $2.2 \times \frac{1}{a}$

Quiz control 5/1/2025

Name ID

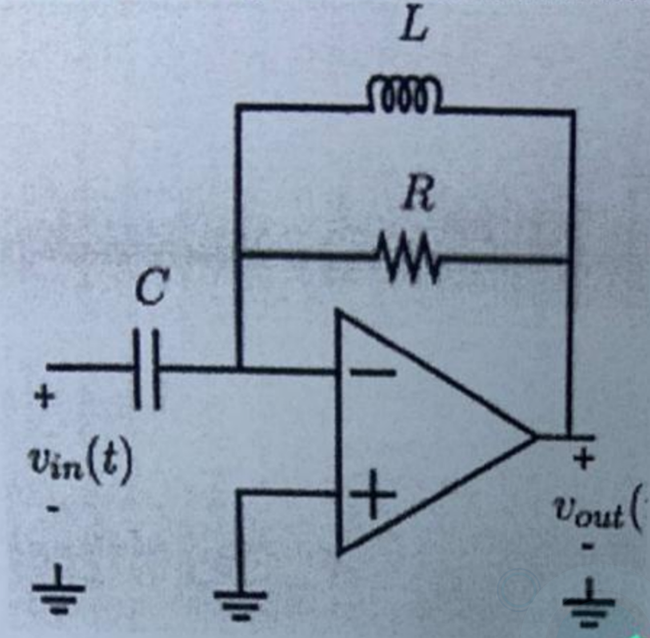
$-R_f C s$

Model the following and find the transfer function



$-\frac{Z_2}{Z_1}$ $\quad -\frac{R_f}{\frac{1}{Cs}}$

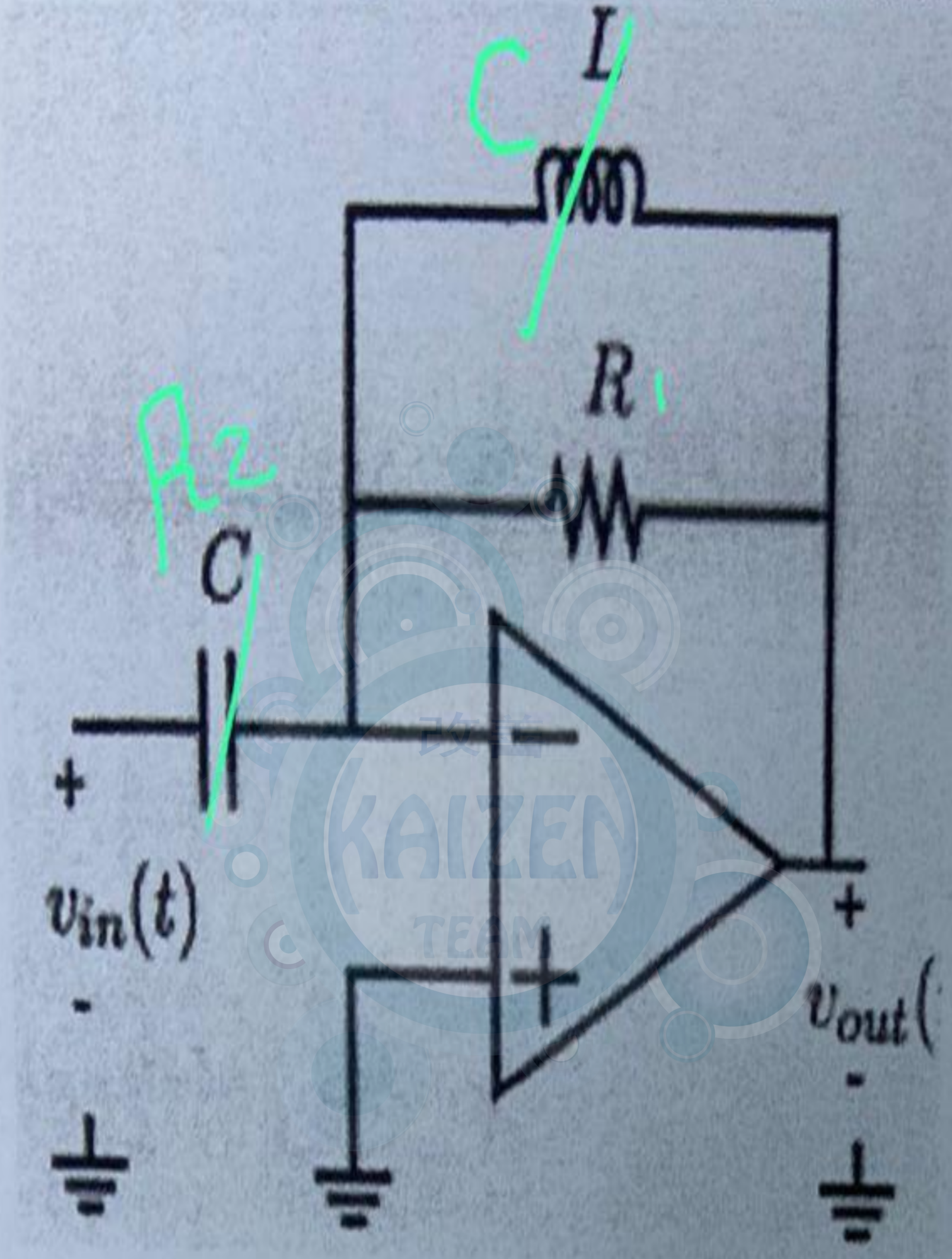
Model the following and find the transfer function



$$-\frac{Z_2}{Z_1} \quad \frac{\frac{LS*R}{LS+R}}{1/CS}$$

$$\boxed{\frac{LRCS^2}{LS+R}}$$

Model the following and find the transfer function



NAME: ID:

For the following system find the rise time, settling time and percent overshoot

$$\frac{C}{R} = \frac{s+3}{s^2+s+4.25}$$

$$\frac{S+3}{S^2+S+4.25} \quad \text{Complex}$$

$$(0.5^2)$$

$$0.25 < 4.25 \quad \zeta$$

$$\omega_n = \sqrt{b} = \sqrt{4.25}$$

$$\zeta = \frac{a}{2\sqrt{b}} = \frac{1}{2\sqrt{4.25}}$$

$$T_r = \frac{\pi - \cos^{-1}\left(\frac{1}{2\sqrt{4.25}}\right)\frac{\pi}{180}}{\sqrt{4.25}\sqrt{1-\left(\frac{1}{2\sqrt{4.25}}\right)^2}}$$

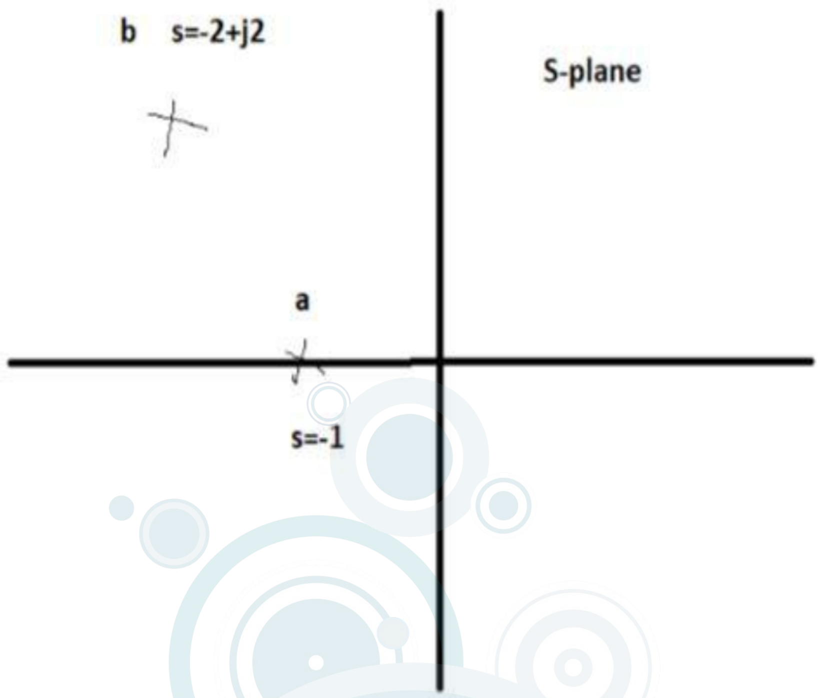
$$0.908$$

$$T_s = \frac{4}{\omega_n \zeta} = 8\,S$$

$$PO\% = 45.6\%$$

A L A D I B Notebook

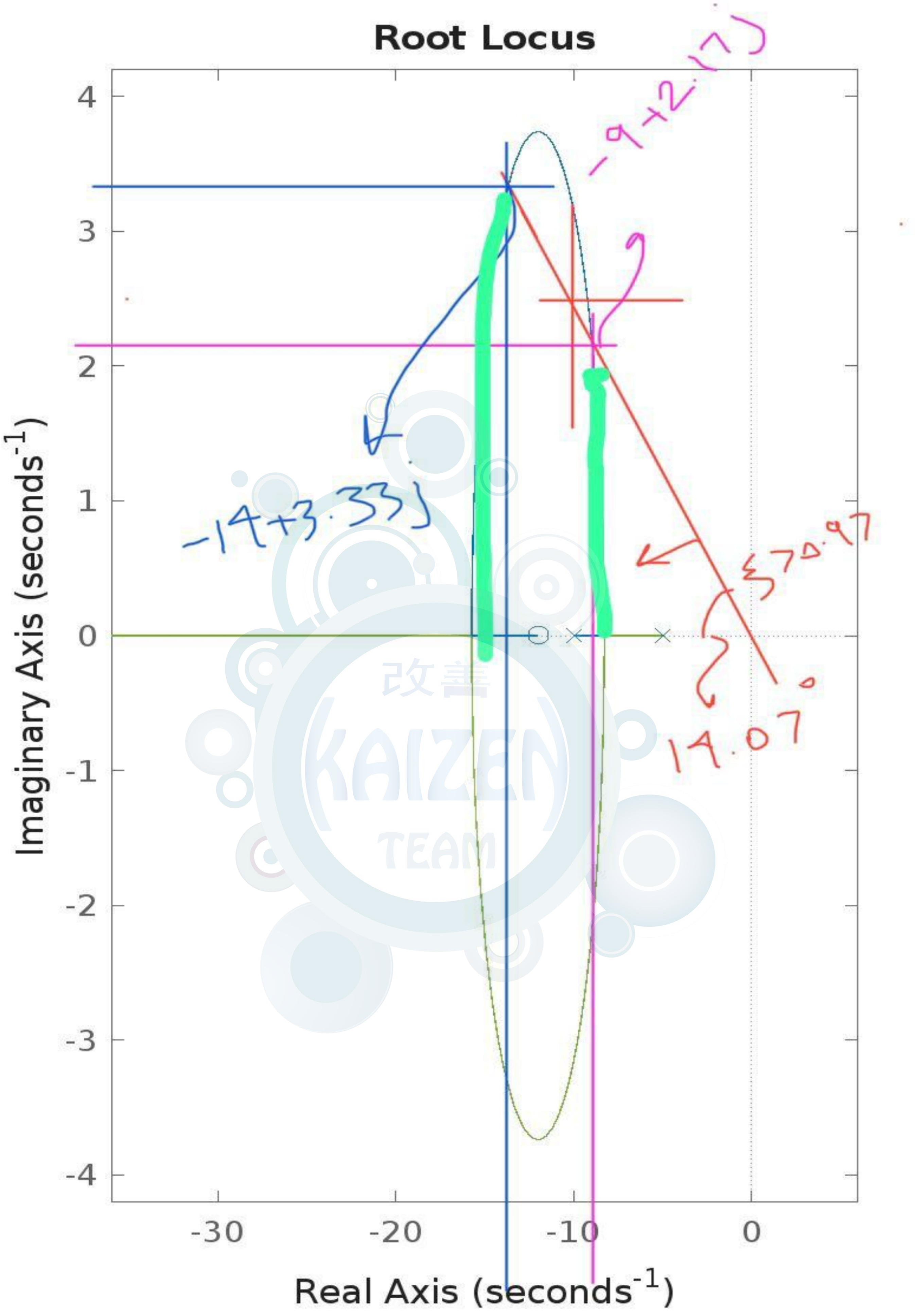
Q5) a) For a and b poles in the following find the associated settling time and percent overshoot (5 points)



Dominat pole $(s+1)$

$T_s = \frac{4}{1} = 4$

Po% $\rightarrow$ ther is no po%
(first order)


Root Locus
Imaginary Axis (seconds^{-1})
Real Axis (seconds^{-1})
4
3
2
1
0
-1
-2
-3
-4
-30
-20
-10
0
$-9+2.17j$
9
$-14+3.33j$
ζ 70.97
14.07°

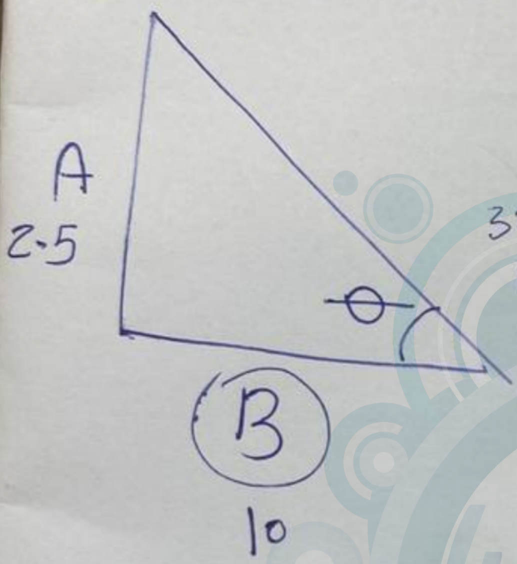
$\xi > 0.97$

$\xi = 0.97$

$\theta = \cos^{-1} 0.97$

$= 14.07^\circ$

$\tan\theta = 0.25 = \frac{A}{B}$



we want bellow the line

$30 \to 10$
$27 \quad ?$

$30 \to 1$
$5 \quad ?$

$30 \to 10$
$12 \to ?$

$30 \to 1$
$10 \to ?$

first point

$-9 + 2.17j = s$

$$\frac{K(s+12)}{(s+10)(s+5)} = 1$$

Case $\boxed{1}$

$K = 2.94$

$K < 2.94$

second point

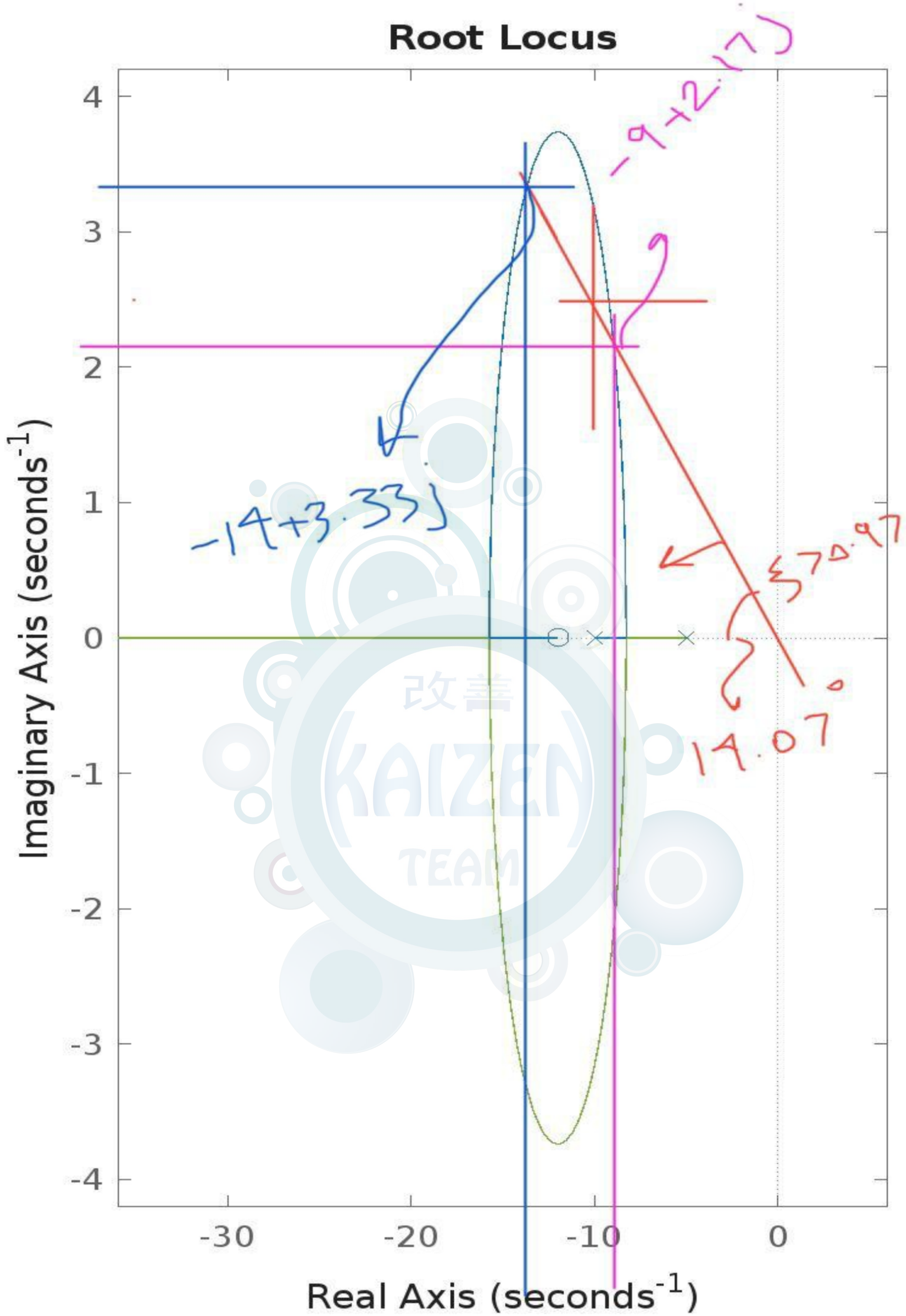
$-14 + 3.33j$

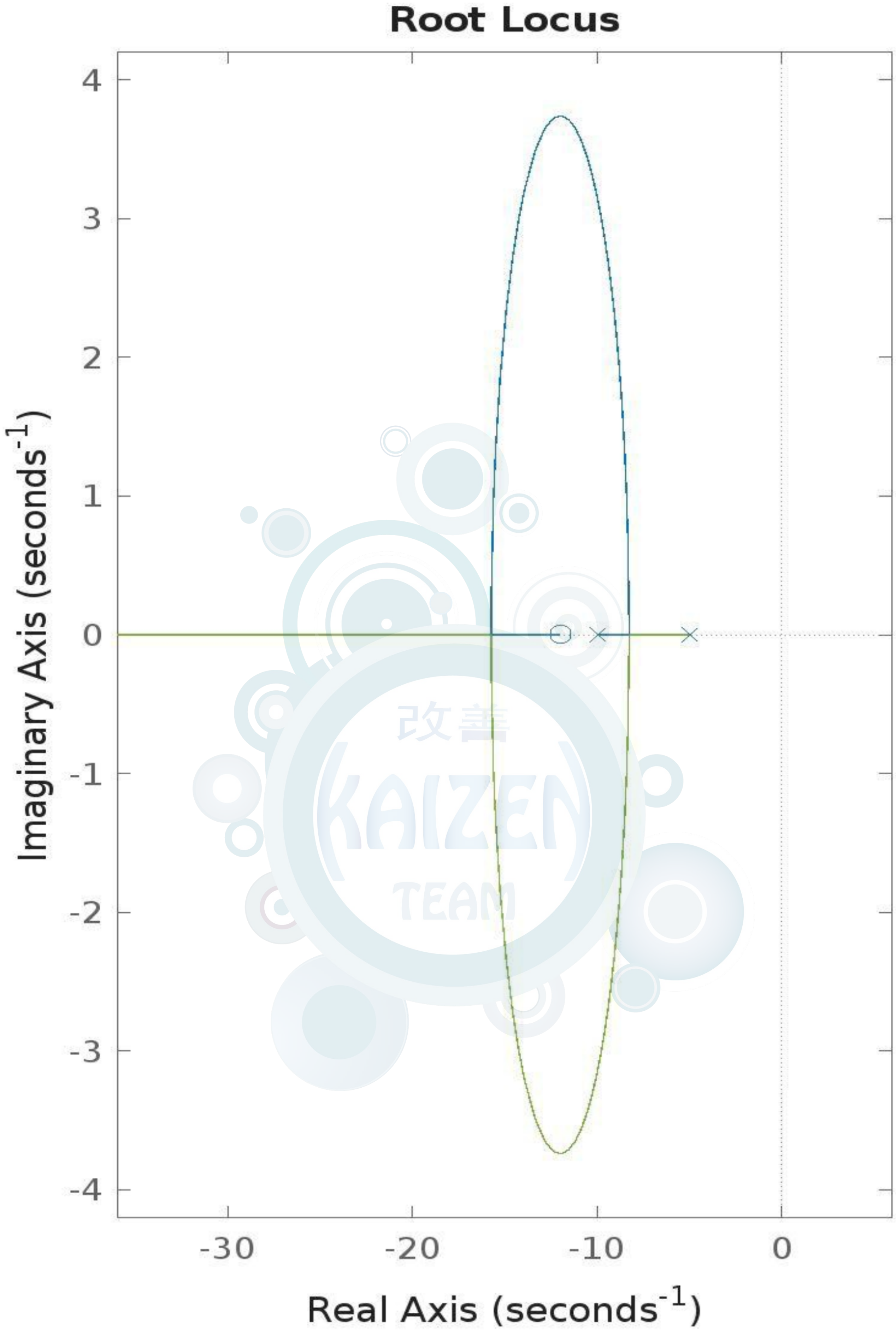
$$\frac{K(s+12)}{(s+10)(s+5)} = 1$$

$K = 12.86$

$K > 12.86$

Case $\boxed{2}$


Root Locus
Imaginary Axis (seconds-1)
Real Axis (seconds-1)
4
3
2
1
0
-1
-2
-3
-4
-30
-20
-10
0
-9+2.17j
-14+3.33j
14.07°

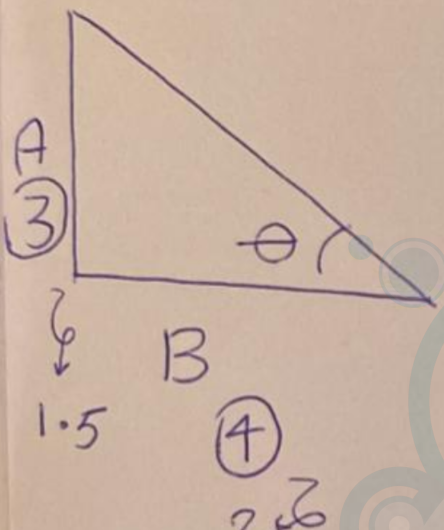

Root Locus
Imaginary Axis (seconds^{-1})
Real Axis (seconds^{-1})
4
3
2
1
0
-1
-2
-3
-4
-30
-20
-10
0

$\xi > 0.8$

$\theta = \cos^{-1} 0.8$

$= 36.87^\circ$

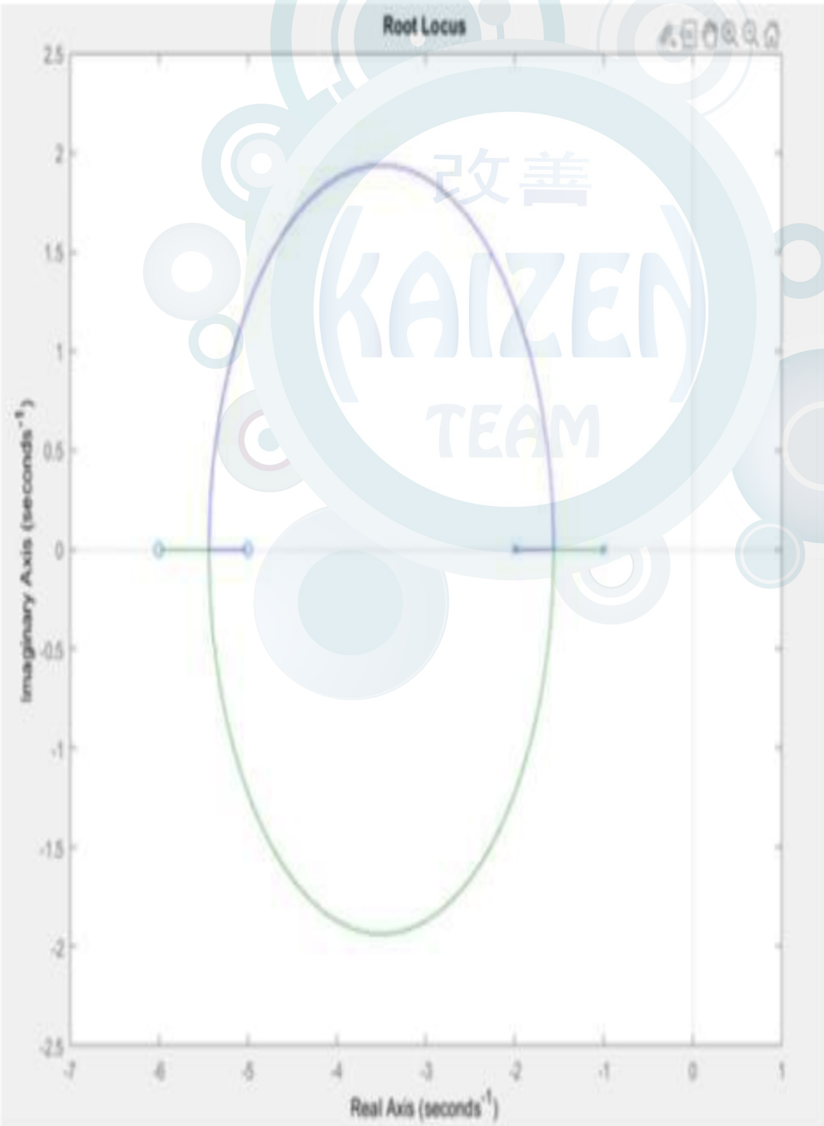
$\tan \theta = 0.75 = \dfrac{A}{B}$

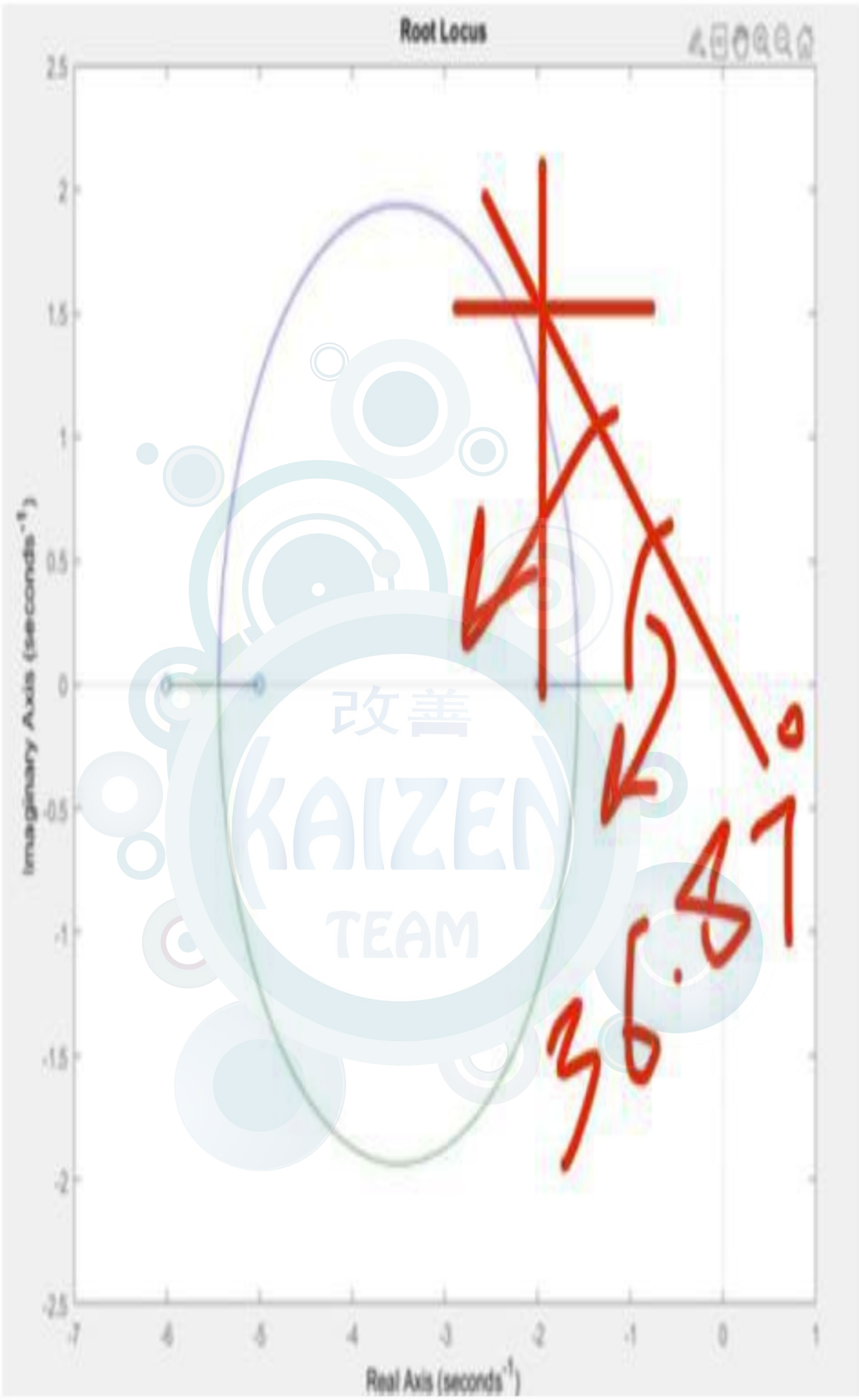


we want under the line So all points satisfy the Constraint

$$\frac{(S+5)(S+6)}{(S+1)(S+2)}$$

Q2) a) For the following system $G = \frac{(s+5)(s+6)}{(s+1)(s+2)}$, H=1 design the feedback controller k to achieve a damping ratio of > 0.8. (you must use the root locus figure below) (7.5 points)




Root Locus
Imaginary Axis (seconds⁻¹)
Real Axis (seconds⁻¹)
36.87°
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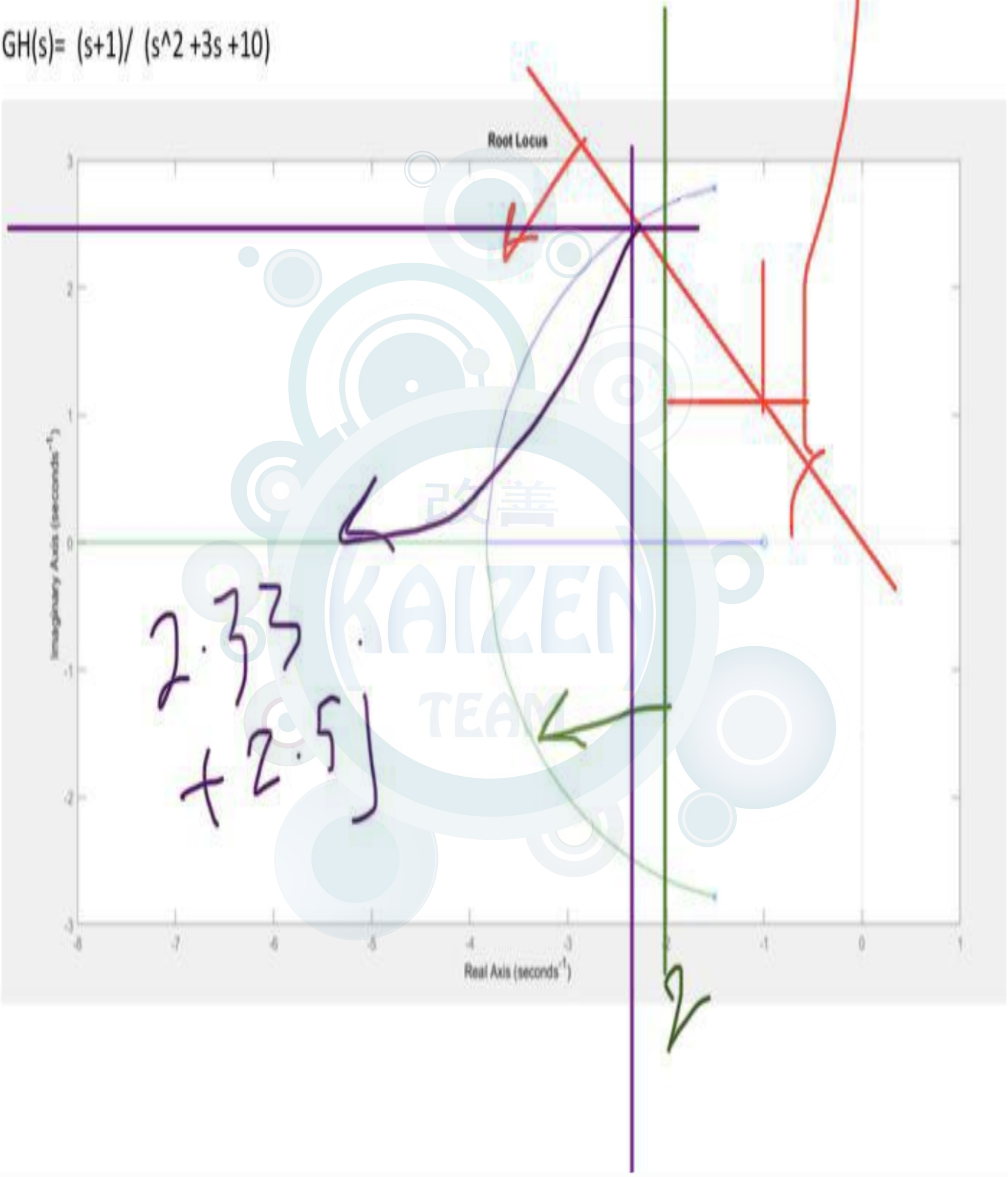
45.57°

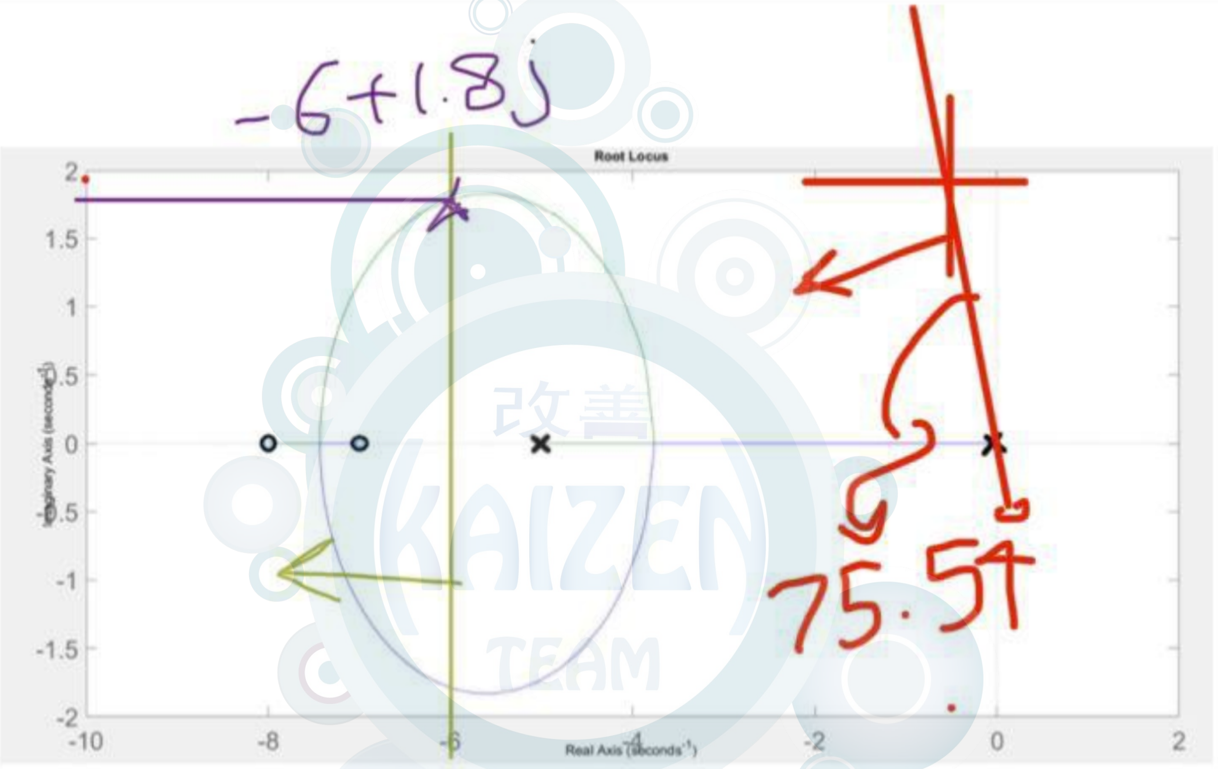
Name ID

For the following system determine K that achieves a damping ratio of > 0.7 and settling time < 2 s

GH(s)= (s+1)/ (s^2 +3s +10)



[redacted]

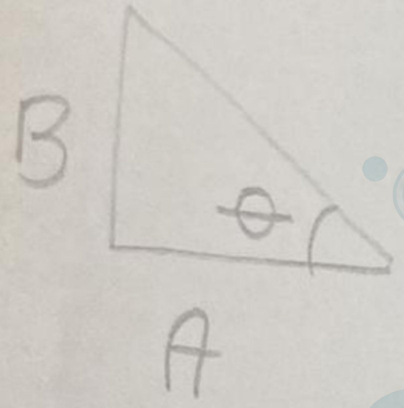


[redacted]

$\xi > 0.7$

$\theta = \cos^{-1} 0.7 = 45.57^\circ$

$\tan\theta = 1.02 = \frac{B}{A} \quad \frac{1.02}{1}$



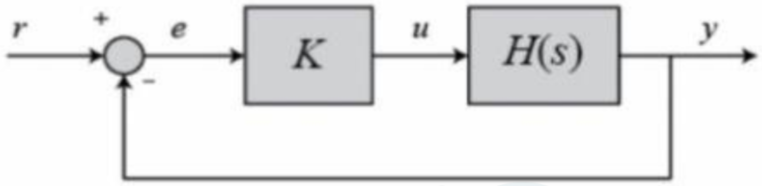
we want under the line

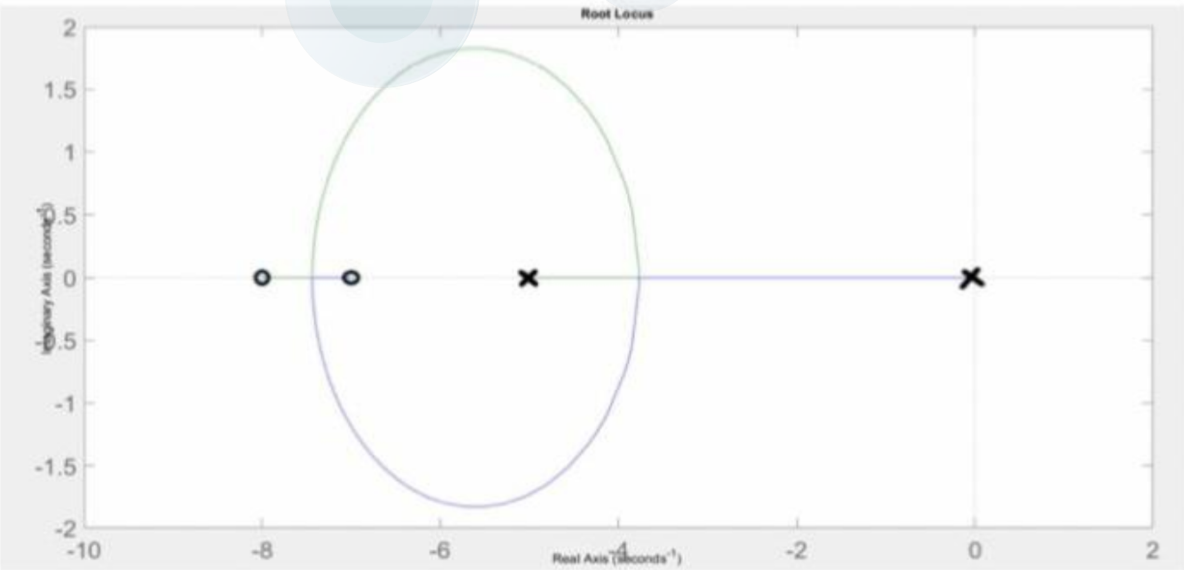
$T_s < 2$

$\frac{4}{\omega\xi} = 2 \qquad \omega\xi = 2$

Not possible !!

Q6)What is the) a) For the following system $H(s) = \frac{(s+7)(s+8)}{s(s+5)}$ design the feedback controller k to achieve settling time < 0.666. (you must use the root locus figure below) (5 points)





extra

$PO\% \leq 25\%$

$0.25 = \exp \frac{-\pi \xi}{\sqrt{1-\xi^2}}$

$\xi = 0.404$

$\theta = \cos^{-1} 0.404$

$\theta = 75.54^\circ$

$\tan\theta = 3.88 = \frac{A}{B}$

A

$\hookrightarrow$ 1.94

B

$\hookrightarrow$ if 0.5

$10 \longrightarrow 0.5$

$? \quad 0.44$

$? = 8.8$

We want bellow the line

$10 \rightarrow 0.5$

$6 \quad ?$

$T_s < 0.666$

$\frac{4}{\omega\xi} = 0.666$

$\omega\xi = 6$

we want to the left of the line

$S = -6 + 1.8j$

$\frac{k(S+7)(S+8)}{S(S+5)} = 1$

$k = 2.33$

$\boxed{k > 2.33}$

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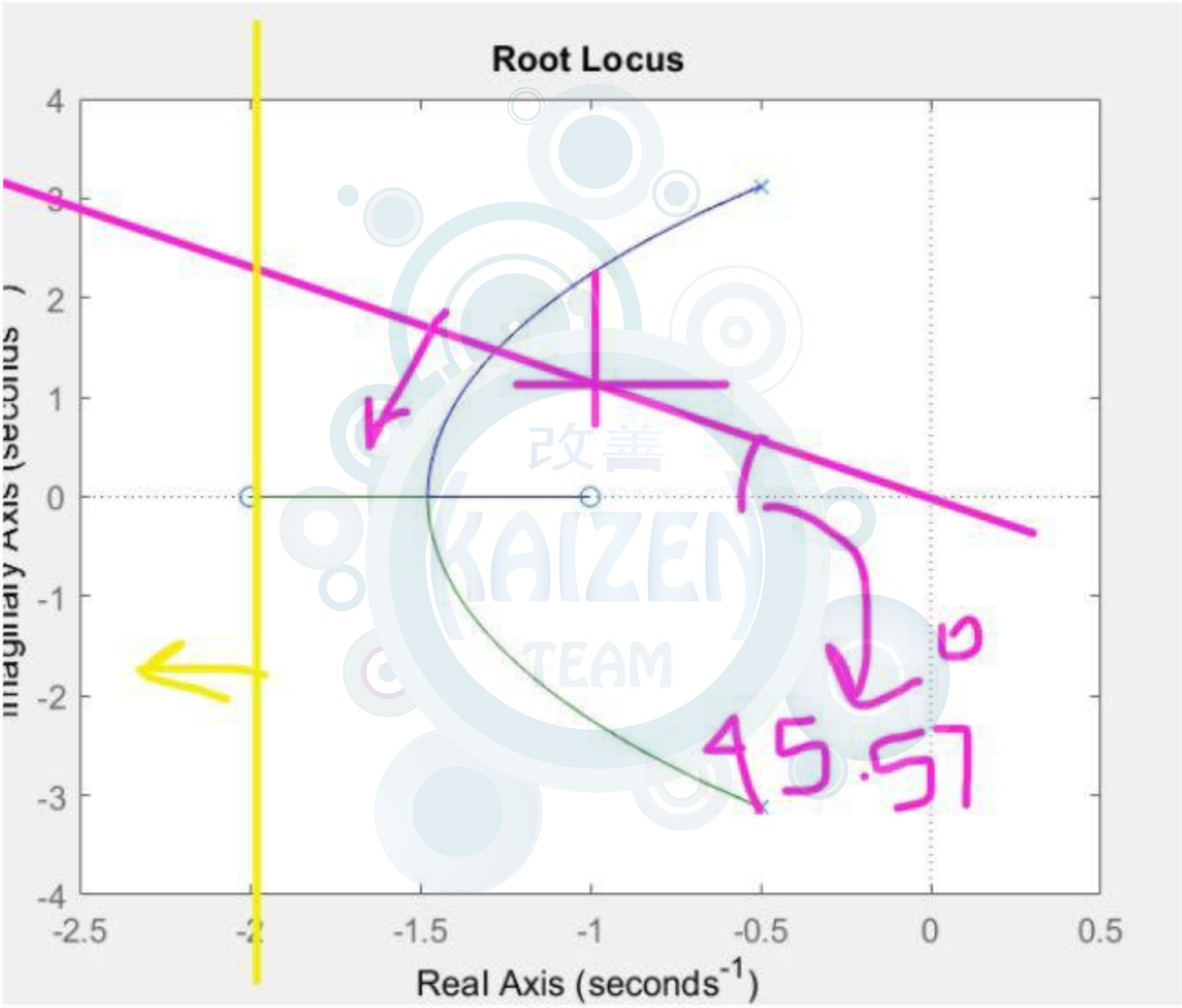
following system determine K that achieves a damping ratio of > 0.7 and settling time < 2 s

(s+1)(s+2)/((s^2 +s +10))



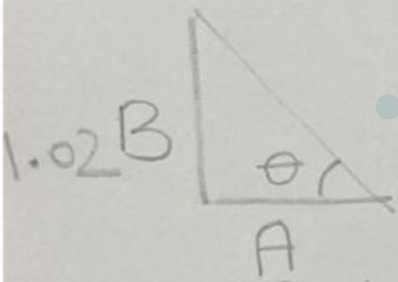
$\xi > 0.7$

$\xi = 0.7$

$\theta = \cos^{-1} 0.7$

$= 45.57^\circ$

$\tan\theta = 1.02 = \frac{B}{A}$



if 1

we want bellow the line

our point →

$S = 2.33 + 2.5j$

→ substitute into equation

$10 \to 1$

$? \quad 0.02$

$t_s < 2$

$\frac{4}{\omega\xi} = 2$

$\boxed{\omega\xi = 2}$

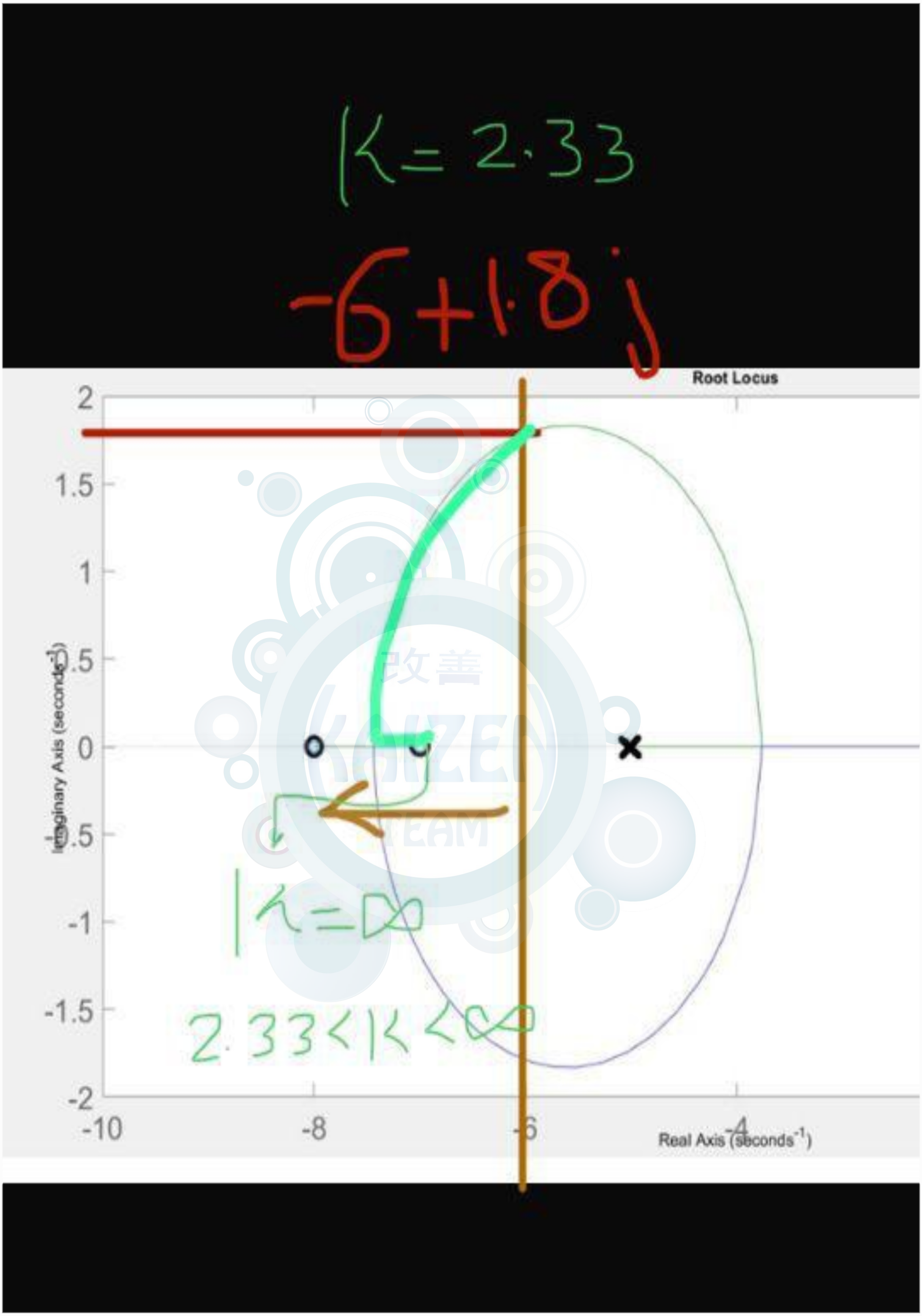
we want the left of the line

$15 \to 1$

$5 \quad ?$

$\frac{K(S+1)}{S^2+3S+10} = 1$

$K > 1.66$



K = 2.33
-6+1.8j
Root Locus
Imaginary Axis (seconds^-1)
Real Axis (seconds^-1)
K = ∞
2.33 < K < ∞

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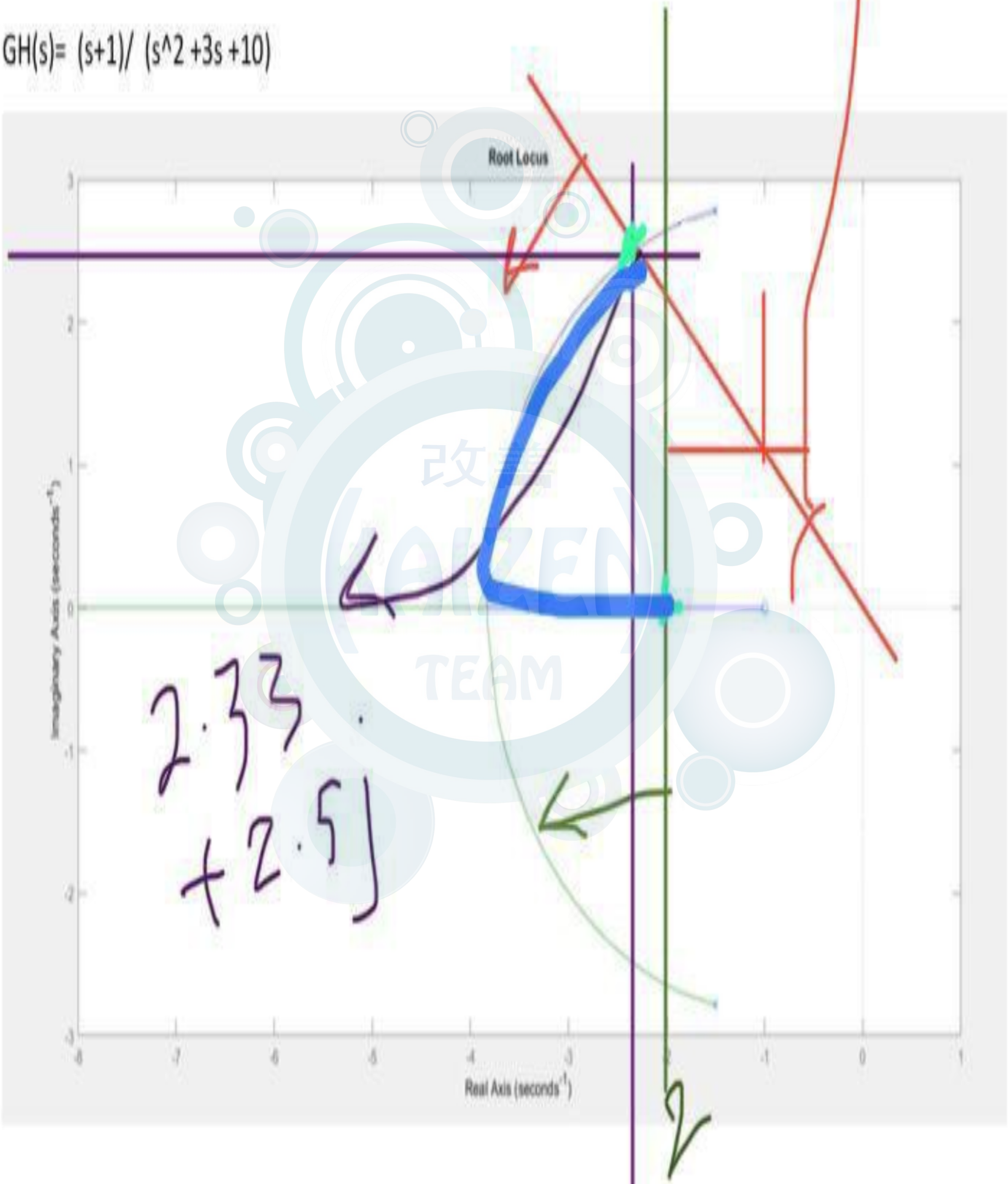
45.57°

Name ID

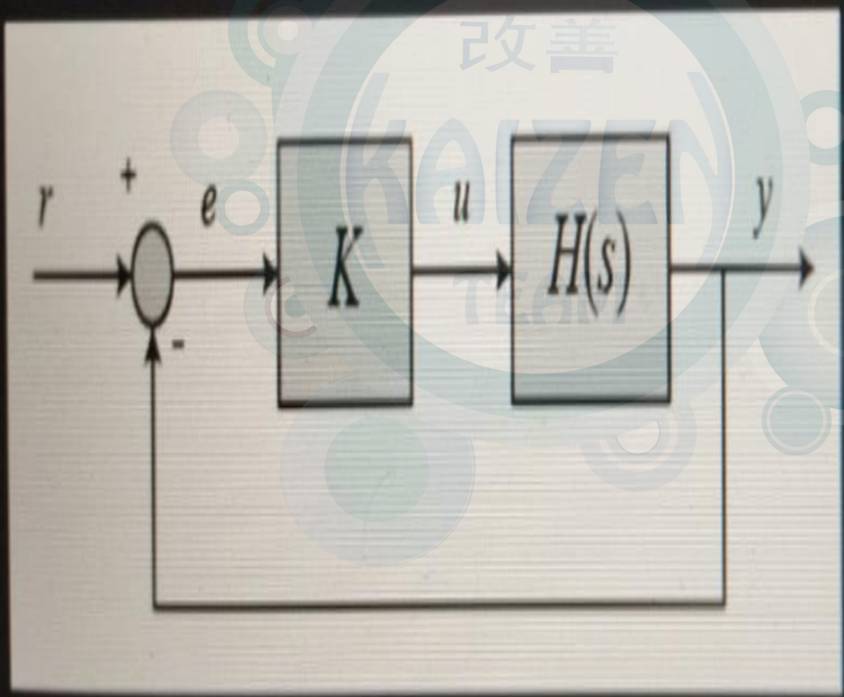
For the following system determine K that achieves a damping ratio of > 0.7 and settling time < 2 s

GH(s)= (s+1)/ (s^2 +3s +10)



Tools Stencils Edit Convert Insert Replay Help

Q6)What is the) a) For the following system $H(s)=\dfrac{(s+7)(s+8)}{s(s+5)}$ design the feedback controller k to achieve settling time < 0.666. (you must use the root locus figure below) (5 points)



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Name ID

For the following system determine K that achieves a damping ratio of > 0.7 and settling time < 3 s

GH(s)= (s+1)* (s+2)/((s^3 +3s +10))

45.57°

1.33

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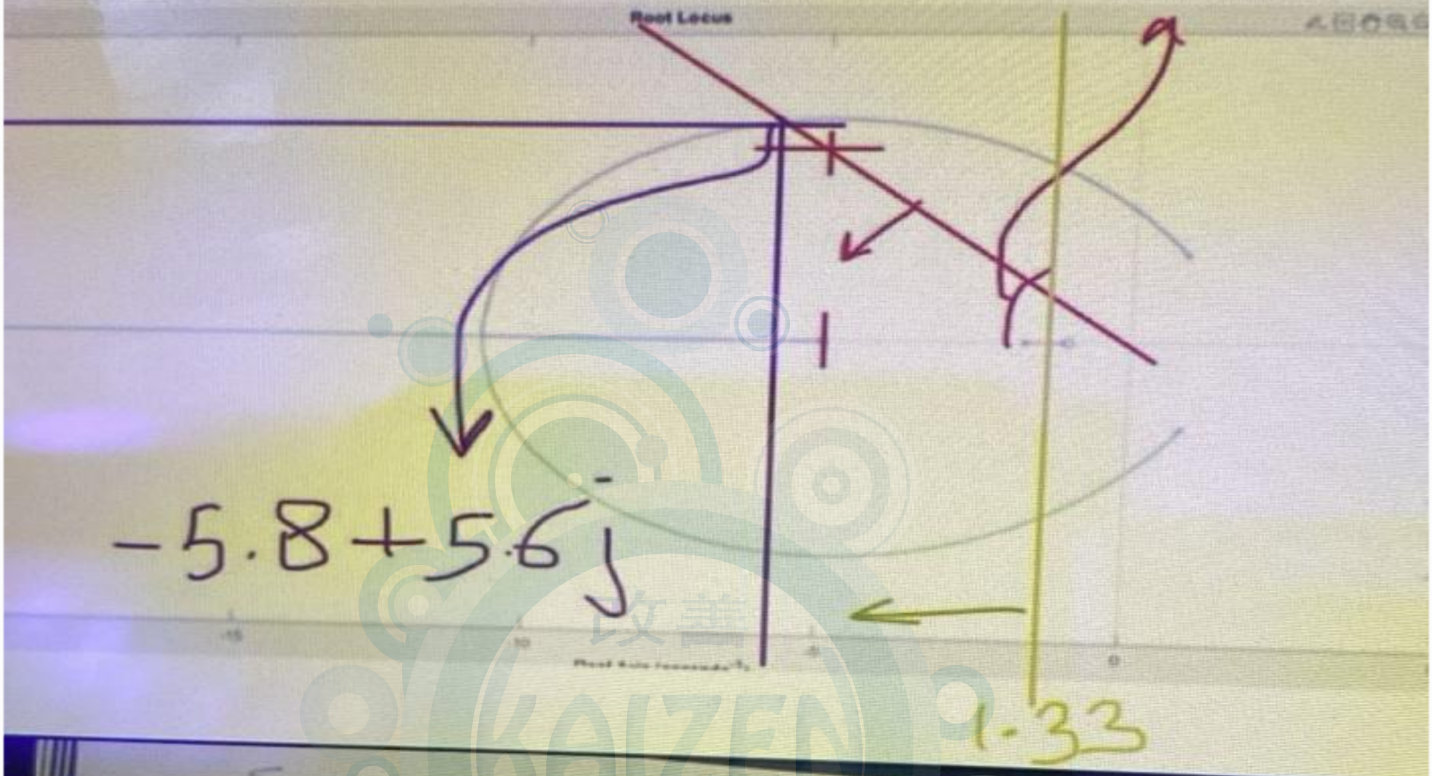
ollowing system determine K that achieves a damping ratio of > 0.7 and settling time < 3 s

;+1)* (s+2)/((s^3 +3s +10))

45.57°



$\xi = 0.7$

$\theta = \cos^{-1} 0.7$

$= 45.57^\circ$

$\tan\theta = 1.02 = \frac{B}{A}$

if we assumed $A = 5$

B will be 5.1

① $10 \to 2$

$\to 1.1$

for $\xi > 0.7$ we will take the Area under the line

Quiz 8 Industrial control systems Prof M. Barghash IE Dept Sch of Eng UoJ 22/8/2023

Name: ID:

write MATLAB code using ODE45 to solve the following differential equations

$$\ddot{x} + x = \log(t), \qquad \dot{x}(0) = 0,\ x(0) = 0$$

Plot(y) and plot(x) on same figure for a time interval 0 to 20 seconds.

Quiz control 5/1/2025

Name ID

Model the following and find the transfer function

For the following write the control system tool box to find the rootlocus and step response

$$G=\frac{1}{(s+3)(s^2+2)}$$

```
num=[1];
den=conv([1 3],[1 0 2]);
g=tf(num,den)
rlocus(g)
step(g)
```

Quiz control 5/1/2025

Name ID

Model the following and find the transfer function

For the following write the control system tool box to find

```
num=[1];
den=[1 2 7];
g=tf(num,den)
rlocus(g)
step(g)
```

$$G=\frac{1}{(s^2+2s+7)}$$

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