ElCoM
ELECTRICAL COMPUTER MECHATRONICS

تقدم لجنة ElCoM الاكاديمية

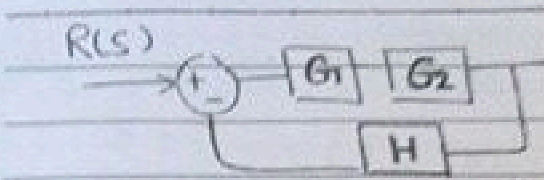
تلخيص لمادة:

مختبر تحكم آلي

15/7/2019
Tuesday

No. control lab.

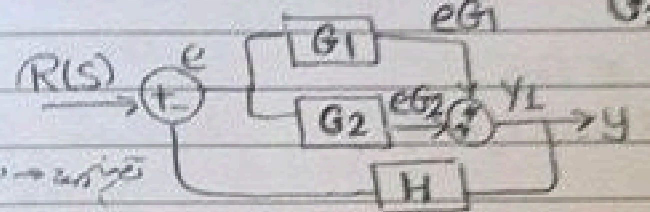
functions :-
- polyval
- conv
- roots
- series
- feedback
- parallel
- zero
- pole
- step
- minreal
- dc gain
- damp
- tf



"Block diagram"

$G_1 = \frac{1}{s+2}$ polynomial

$G_2 = \frac{s^2+2}{2s^2-3s+4}$



P → Kp → [illegible]

P → Kp
I → Ki → Poles [illegible]

اذا حطالك G1, G2 عادي
بالـ polyval بيطلع error

① [illegible]
[illegible]
أو ② بنستخدم الـ Matrix

بنسترجع الـ command الي كتبناهم
بطريقتين :-
① عن طريق الاسهم ↓ ↑
وضع اول حرف من comm
[illegible]

أو ② عن طريق الـ command history window
بتكون على الشمال.

إذا حطيت فاصلة منقوطة آخر الـ command
ما بتكون النتيجة بعد الـ command
ما بتظهر لكن بتحط في work space

[illegible] "command window"

Instruction

[] [illegible]
( ) [illegible]

```
a = [1]
b = [1 2]
Polyval (a,0)
Polyval (a,-10)
```

بتعوض قيمة عند 0
بتعوض قيمة [illegible]

تعويض [illegible]

[illegible] a
1 = [illegible]

```
q=polyval(b,0)
q=2
```

← square prac.

Kp → زيادة

```
c=[1 0 2];
q=b*c
q=b.*c
```

error
b,c [illegible] مش نفس size.

conv
ضرب 2 polynomial ببعض

الحل التكاملي convolution

```
q=conv(b,c)
q=[1 2 2 4]
```

الجواب

جذور الـ polynomial
[illegible]
roots

```
roots(q)
```

← round prac.
[illegible] 3root

```
V=[1 2 3 4 5]
I=[1 5 7 6 3]
r=V/i
Y=V./i
[_ _ _ _]
```

error
[illegible] element

الفرق بين clc , clear

clc بتمسح الشاشة لكن ما بتمسح قيم المتغيرات

clear بتمسح كل شي وكل القيم

[illegible] [.] [illegible] per element

Polyval → [illegible] f(x) [illegible]

Conv: → تضرب المعادلات ببعض

Roots: [illegible]

يجب وضع dot [illegible]

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tf. [illegible]

series ← ضرب [illegible]
parallel ← جمع [illegible]

No.

$G_1 = tf(a,b)$ transfer func.
بسط مقام

$Y/R = \frac{G_1G_2}{1 \mp G_1G_2H}$

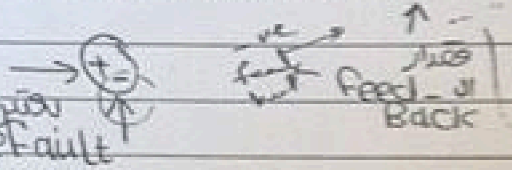
$G_2 = tf(c,[2\ -3\ 4])$

$\frac{F}{1 \mp FH}$

$Fw = G_1 * G_2$
F = series(g1,g2) [illegible] series transfer func.

[illegible]

YR = feedback(F,1)



-1 [illegible] By default

$\frac{s^2+2}{2s^3+2s^2-2s+10}$

unstable [illegible]
3 [illegible] order [illegible]

[illegible]
feedback(for, feed, ±1)
sign

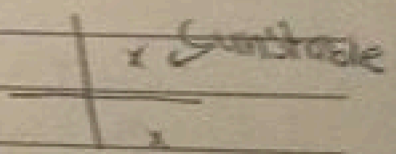
[illegible] +ve feed-back [illegible] +1 [illegible]

zero(YR) 2 [illegible] 0+1.4142i
0-1.4142i

pole(YR)
-2.3403
0.6701+1.2991i
0.6701-1.2991i
→ unstable

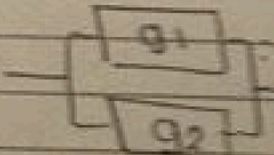
3 [illegible]
order [illegible] 3

[illegible] real [illegible]
right [illegible]
side



unstable → steady state value

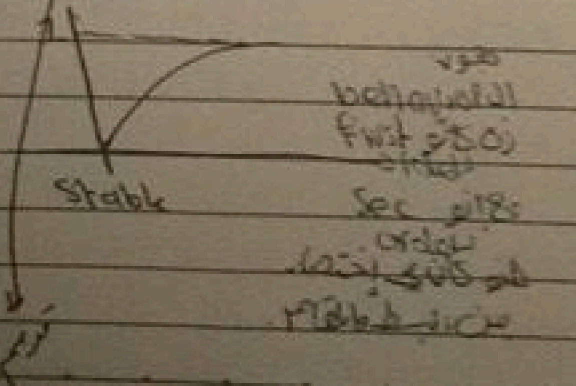
$f = g_1 + g_2$
FF = parallel(g1,g2)



[illegible] transfer func. ~> step(ans)

[illegible] response

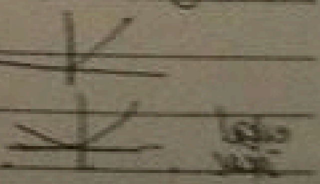
Stable → Bounded



[illegible] behavior first [illegible] Sec order [illegible]

d = min real(a)
step d

IC y'(0)=0 y(0)=0



step

15/7

No. 5

$$\lim_{s\to 0} s\,Y(s) = \lim_{s\to 0} s\,T(s)\,R(s)$$ to find steady state value

$$= \lim_{s\to 0} \cancel{s}\,\frac{1}{s+1}\,\frac{A}{\cancel{s}} = A$$

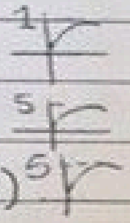
إذا كان الـ input unit step function

r = 5 * d

Step (a)

Step (r)

Step (5*a)



[illegible]

step

dc gain (d)

ans = 1

dc gain (5*d)

ans = 5

لو 1st بتطلع الـ τ , gain

dc [illegible]

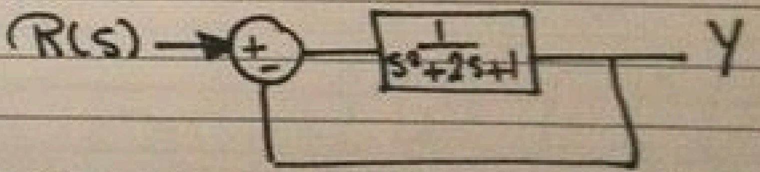
damp (a) →

بتستخدم للـ 2nd order

بتطلع الـ ζ ; damping Ratio

ωn ; natural freq.

Simulink newmodle



minue

continous ▶ transfer fcn
integrator

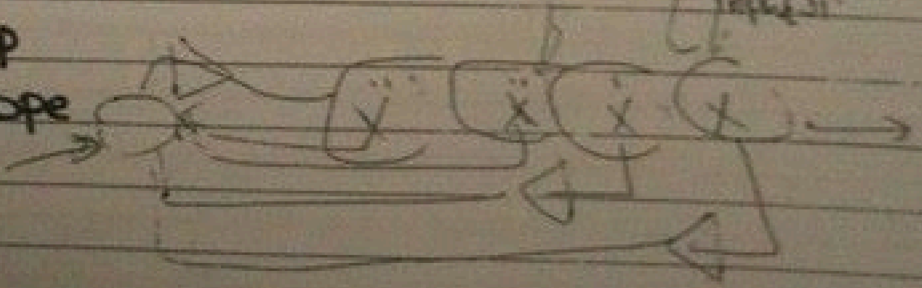
Mathoperation ▶ sum
gain

list of sign
1 + -

[illegible]

Source ▶ step

Sinks ▶ scope



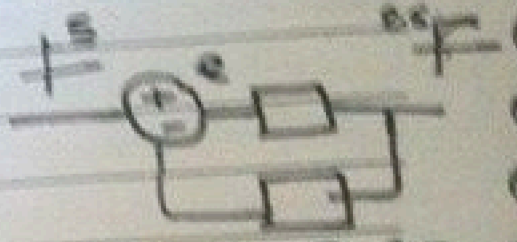
No.

$$m\ddot{x}+b\dot{x}+cx=r(t)$$

$$ms^2X(s)+bsX(s)+cX(s)=R(s)$$

$$m(s^2X(s)+sX(0)+\dot{x}(0))$$

initial value نفرض ال ب zeros



error = 5-2.5

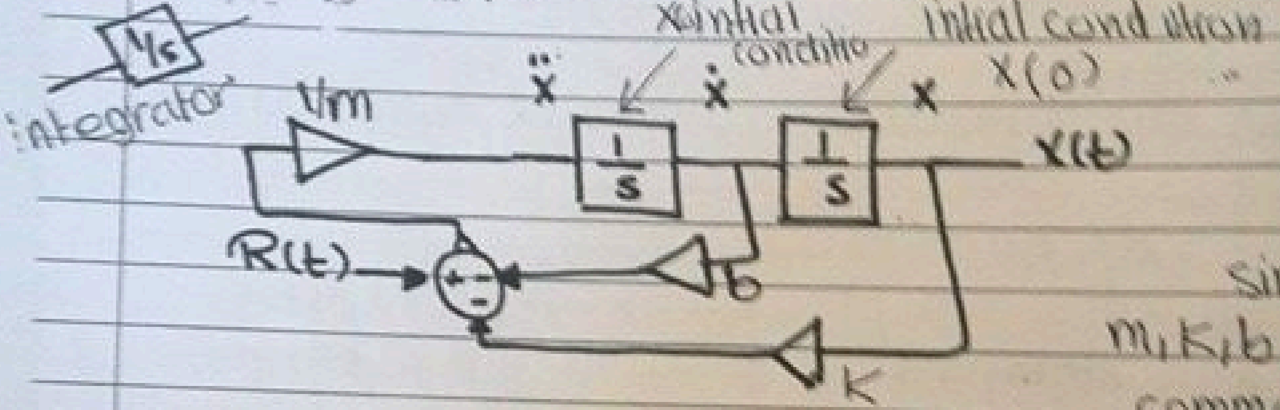
$$m\ddot{x}+b\dot{x}+kx=r(t)$$

$$\ddot{x}+\frac{b}{m}\dot{x}+\frac{k}{m}x=\frac{r(t)}{m}$$

① بنخليها ال $\ddot{x}$ لـ 1

② بنحول [illegible] في طرف بعض

$$\ddot{x}=\frac{1}{m}(r(t)-b\dot{x}-kx)$$

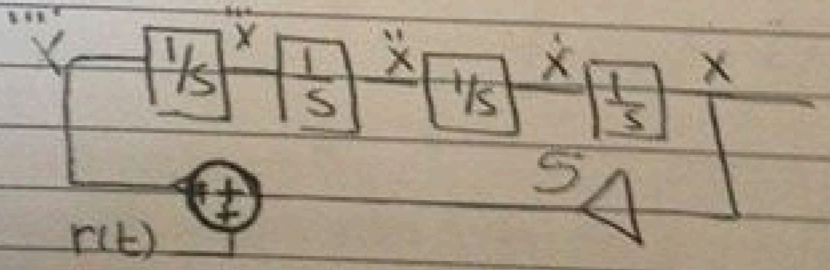


بنعمل ال Block diagram في simulink

وبنعطي قيم ال m,k,b في ال command window

$$\overset{....}{X}-5X=r(t)$$

$$\overset{....}{X}=5X+r(t)$$



* e = desired value - actual value

closed loop $\frac{Y}{R} = \frac{G}{1+G}$

* sensitivity

$$S_G^T = \frac{\partial T}{\partial G} \times \frac{G}{T} = \frac{\Delta T}{\Delta G} \frac{G}{T}$$

G↑, ↓S 22/7/2014

- ↑G ↓e (closed loop)
- ↑G ↑e (open loop)

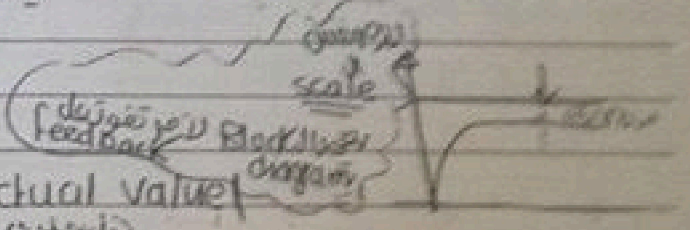
open loop, closed loop

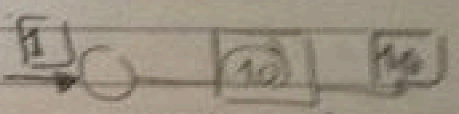
unstable ← sys [illegible] closed loop [illegible]

1) Accuarcy (error [illegible])

measurment of error

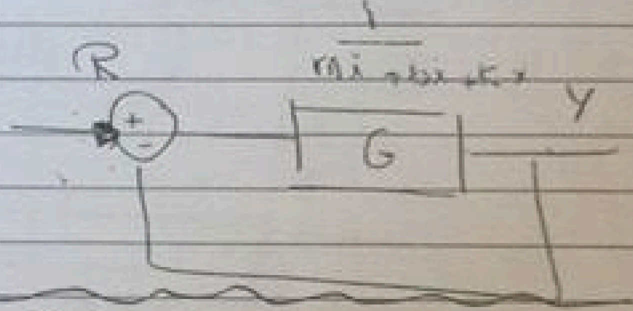
e = |desired value - actual value|
(Input) (output)





e = 10 - 1 = 9
open loop is bad

e↑ a↓



closed

$\frac{Y}{R} = \frac{G}{1+G}$

closed loop
open loop

S_G^T

2) sensitivity

S_G^T (تأثير التغير في G على T)

m, b, k parameter

0 < S < 1

$$S_G^T = \frac{\partial T}{\partial G} \times \frac{G}{T}$$ ✓

from curve

$$\boxed{\frac{\Delta T}{\Delta G} \times \frac{G}{T}}$$ ✓

0.5 0.3

ex.

$$\boxed{\frac{Y}{R} = GG_1}$$

$$G_1 \frac{G}{GG_1} = 1$$

↑G , S↓

open loop [illegible]

disturbance
extra input

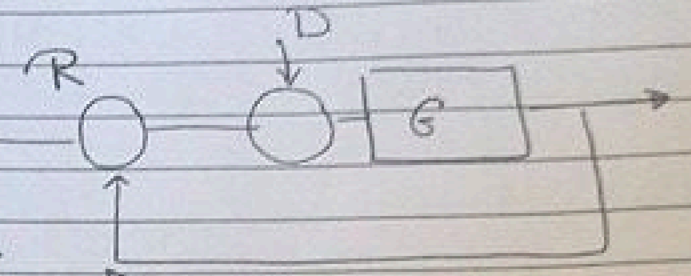
No. ____

disturbance Rejectio (ost condition) → Accuracy [illegible]

extra input.

linear system

[illegible] *
superposition



[illegible]

$Y = \boxed{D=0}\, R + \boxed{R=0}\, D$

gain when D=0

gain when R=0

[illegible]

صفر الدخل التاني

2 [illegible] G

$\boxed{\frac{Y_D}{Y} \times 100\%}$

$\frac{Y_D}{Y} \times 100\%$

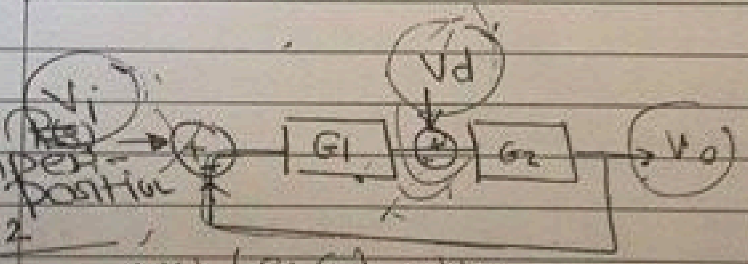
G	D
1	0
2	0
3	0
4	0
1	1
2	1
3	1
4	1

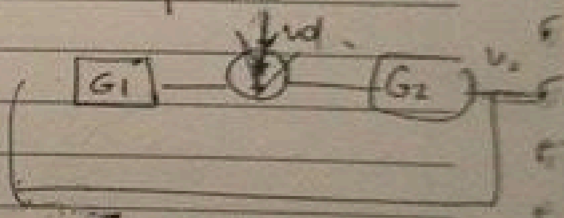
Y_R

$y = Y_R + Y_D$

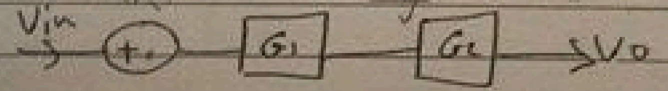
① superposition

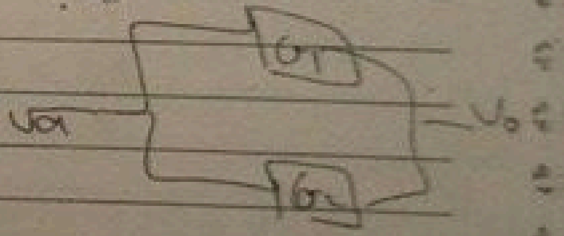
$G_1 G_2$



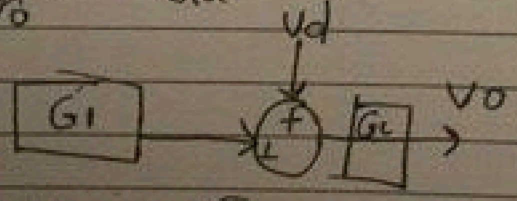


$V_{in}(G_1 G_2) = \frac{V_o}{}$





$\frac{V_o}{V_{in}} = G_1 G_2$ ✓



$\frac{V_o}{V_d} = G_2$

important

curves – parameters   control   3/3/2014

2nd order

$$T.F = \frac{K\omega_n^2}{s^2 + 2\xi\omega_n s + \omega_n^2}$$

K, ξ, ω_n

$$s_{1,2} = -\xi\omega_n \mp j\omega_n\sqrt{1-\xi^2}$$

* $T.F = \frac{K\omega_n^2}{s^2 + 2\xi\omega_n s + \omega_n^2}$

$s_{1,2} = -\xi\omega_n \mp j\omega_n\sqrt{1-\xi^2}$

$\xi = 0$

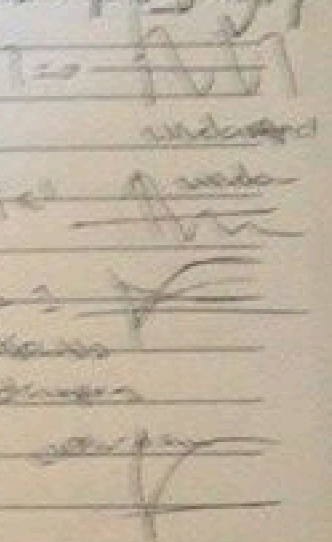
undamped

$\xi < 1$ under

$\xi = 1$

critically damped

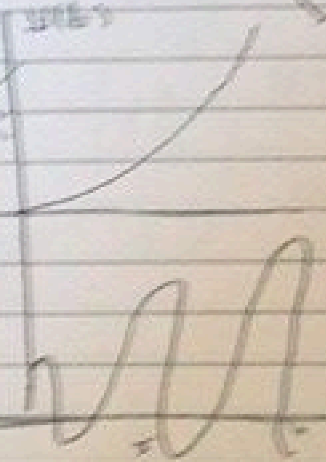
$\xi > 1$



Stable

Real part negative

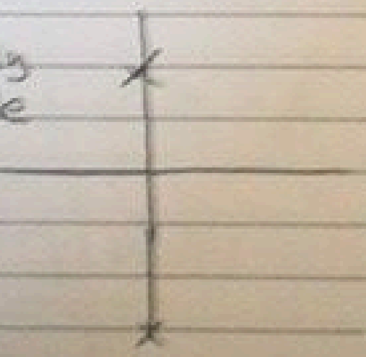
$-\xi\omega_n \mp j\omega_n\sqrt{1-\xi^2}$

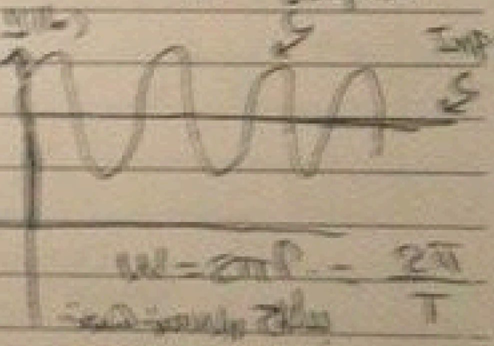


undamped

$\xi = 0 \rightarrow s_{1,2} = \pm j\omega_n$

critically stable

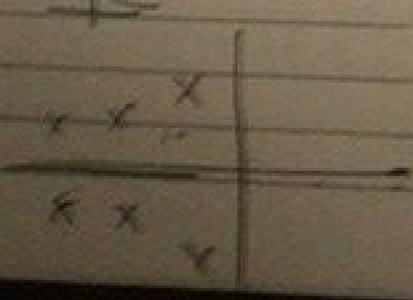


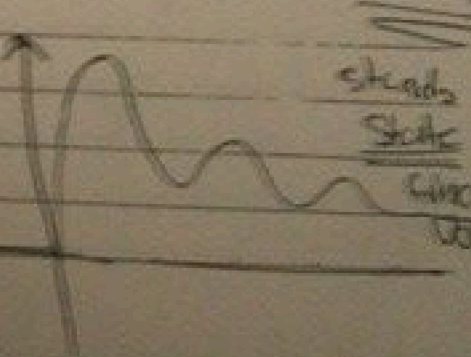


$\omega = 2\pi f = \frac{2\pi}{T}$

$0 < \xi < 1$ (under damped)

e^{-t} $\pm \omega_n$ → give oscillation





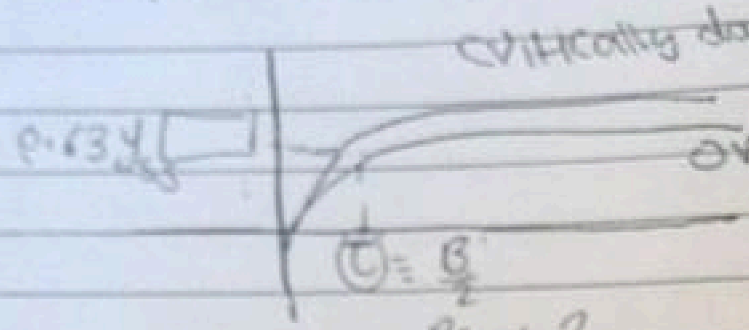
steady state final value

$\frac{4}{\zeta\omega_n}$

$\zeta = 1 \rightarrow s_{1,2} = -\omega_n$

critically damped.

[illegible] system



$\tau = \frac{B}{2}$

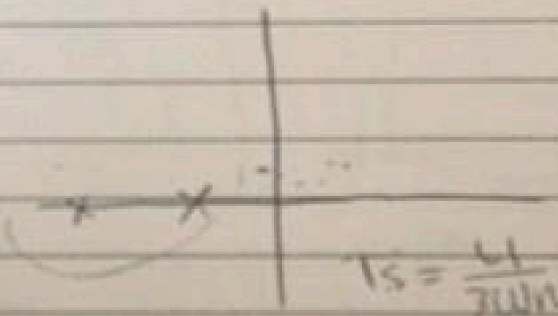
$\frac{Bs}{2} + \frac{2}{2}$

T.F $= \frac{1}{R}$

$\frac{B}{2}s + 1$

$\zeta > 1$ two Real Roots. → overdamped

damping Ratio.



$\frac{10^5}{2}$ $\frac{0.1}{10^5}$

$T_s = \frac{4}{\zeta\omega_n}$

[illegible]

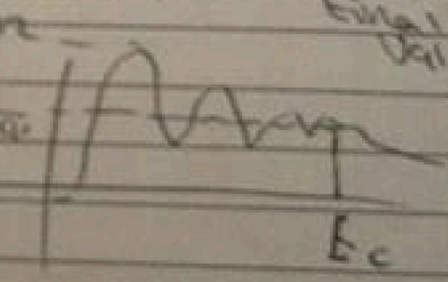
$T_p, T_r, T_s, P.O.$

$\frac{4}{\zeta\omega_n}$

$1 - e^{-t}\sin t$

Sig. from Final Value

under damped

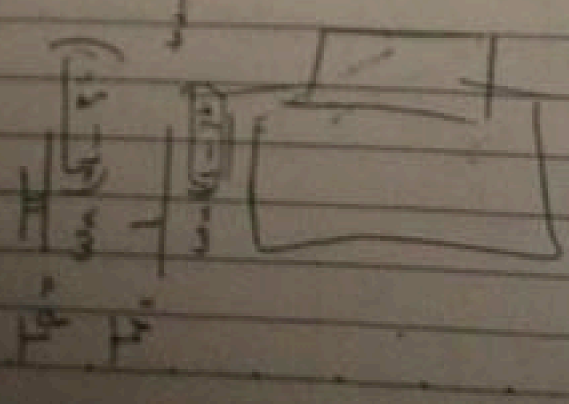


Peak [illegible] = 0

⇓

T_p

T_s



[illegible]

No.

$$\frac{Y(s)}{F(s)} = \frac{1}{ms^2+bs+k}$$

not standard form

$1 = s^2$ [illegible]

[illegible]

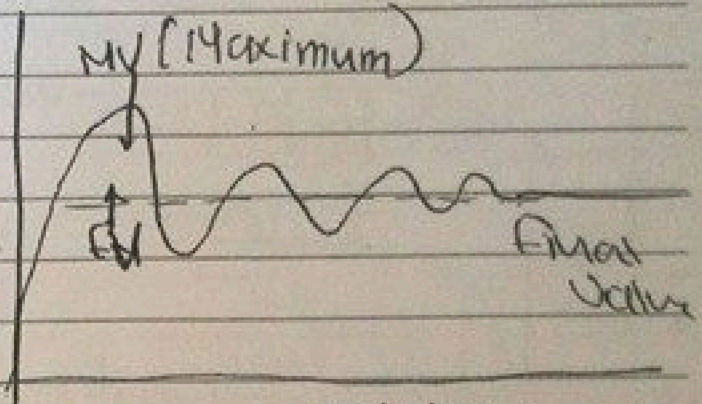
$$= \frac{1/m}{s^2+\frac{b}{m}s+\frac{k}{m}}$$

ممكن تكون بدلالة RC.

$\omega n = \sqrt{k/m}$

$K =$

$\zeta =$



theorical

$$\boxed{Po = 100\, e^{\frac{-\zeta\pi}{\sqrt{1-\zeta^2}}}\ \%}$$

expermintal

$$Po = \frac{MV - FV}{FV} \times 100\%$$

$100\, e^{\frac{-\zeta\pi}{\sqrt{1-\zeta^2}}} \times 100\%$

$K = \frac{FV}{Input}$

$\boxed{K} = \frac{FV}{Input}$

$$\boxed{Po = \frac{MU - FU}{FU} \times 100\%}$$

$$\boxed{Po = \frac{MU - FU}{FU} \times 100\%}$$

[illegible] K [illegible]

$Po = 100\, e^{\frac{-\zeta\pi}{\sqrt{1-\zeta^2}}}\ \%$

$Po = 100\, e^{\frac{-\zeta\pi}{\sqrt{1-\zeta^2}}}$

$Po = \frac{MU - FU}{FU} \times 100\%$

[illegible]

$\frac{Y(s)}{R(s)} = \frac{A}{Bs+1}$

5/8/2014

Control lab. session 5

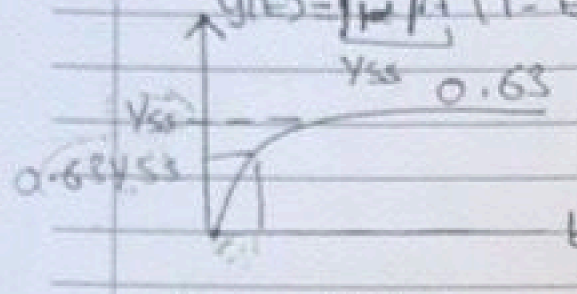
Speed control of servo motor [illegible]

1st order system

$y(t) = [illegible]$

$\frac{Y(s)}{R(s)} = \frac{A}{Bs+1}$ → for the whole system
not for one Block

$y(t) = \underbrace{1 \times A}_{y_{ss}} (1 - e^{-t/B})$



A, B (parameters)
↓
gain

$y(t) = 1 \times A (1 - e^{-t/B})$

$y(t) = 1 \times A (1 - e^{-t/B})$

yss

$y_{ss} = A \times 1 =$

$A = \frac{y_{ss}}{1 \times 1}$

A=

B → factor B (time constant

[illegible]

[illegible]

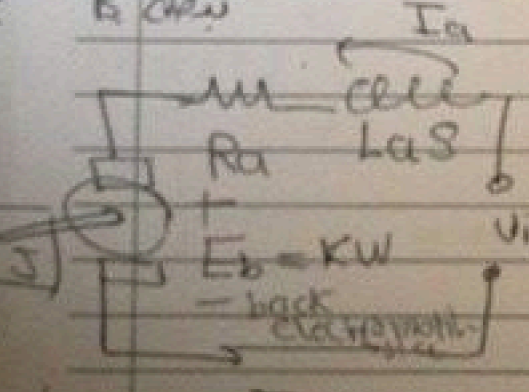
A [illegible]

B [illegible]

$\sum T = J \alpha$

sw

w

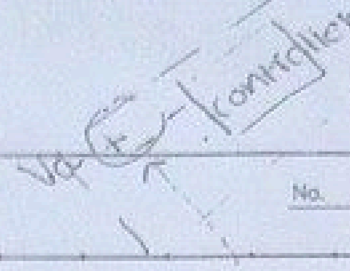


feild constant

$T = K_2 I_a$

$\frac{W(s)}{V_{in}(s)} = \frac{K_m}{\tau_m s + 1}$ } when $L_a = 0$ to Reduce system order

$L_a \neq 0$ → system is second order



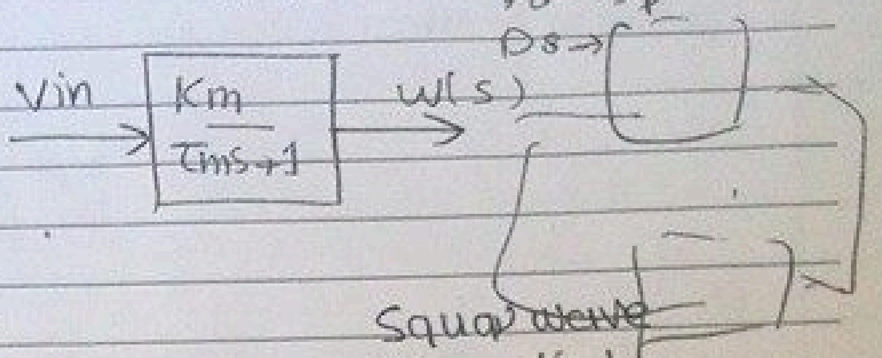
C1 → D2
G2 → B2
D3 → B3
F1 → f6

B3 → f5
f6 → f1 A×
D5 → D4
F8 → F8
D8 →

B1
B2
B3

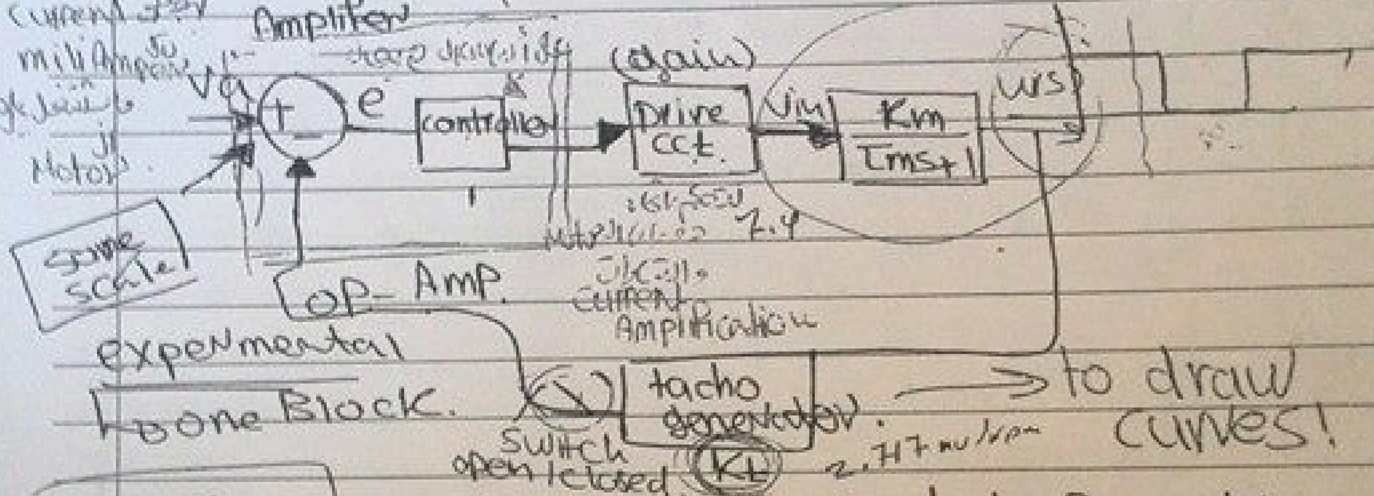
No.

desired speed:-
اللي لازم يتحرك بيها
دلوقتي بحطها بـ arrow
(والـ controller بيعملها)



Km , τm
↓ A ↓ B

Square wave
step input بدل ما



experimental
~~to~~ one Block.

→ to draw curves!

servo Arm
characteristic
servo motor
torque [illegible]

to convert it closed loop system
~~we~~ we need to something convert.
mechanical to electrical (Small generator)
first order.

the resultant parameter of from the curves
are not Km, τm.

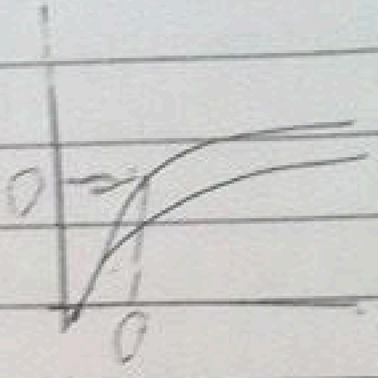
$$\frac{A}{Bs+1}$$

tacho
- voltage given
- ~~speed feedback~~
- speed indicator

Km
Kt
gains

K×

position control

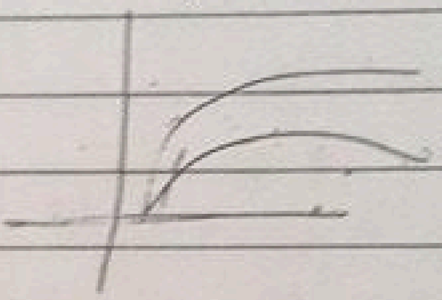


$v \quad x$

$v = \dot{x}$

$w = \dot{\theta}$

$\theta = \int w = \frac{1}{s} w$

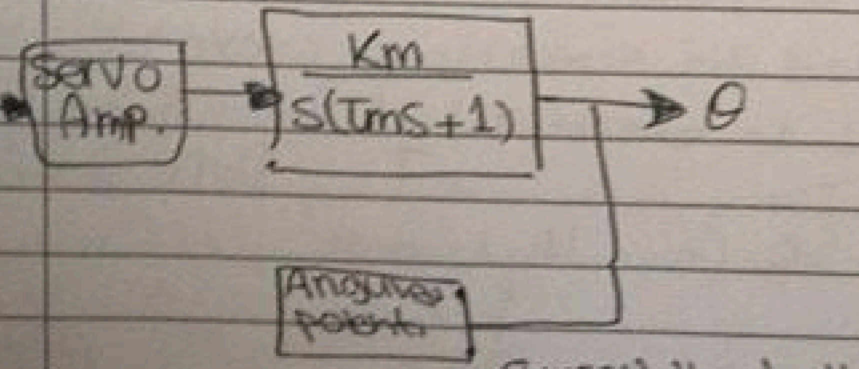


$\theta = \frac{1}{s} w = \frac{1}{s}$

$\frac{\theta}{V_{in}} = \frac{1}{s} \frac{K}{\tau_m s + 1} \quad (la = 0)$

$\theta = \frac{1}{s^2} \frac{K}{\tau_m s + 1}$

$\theta = \int w = \frac{1}{s} w.$

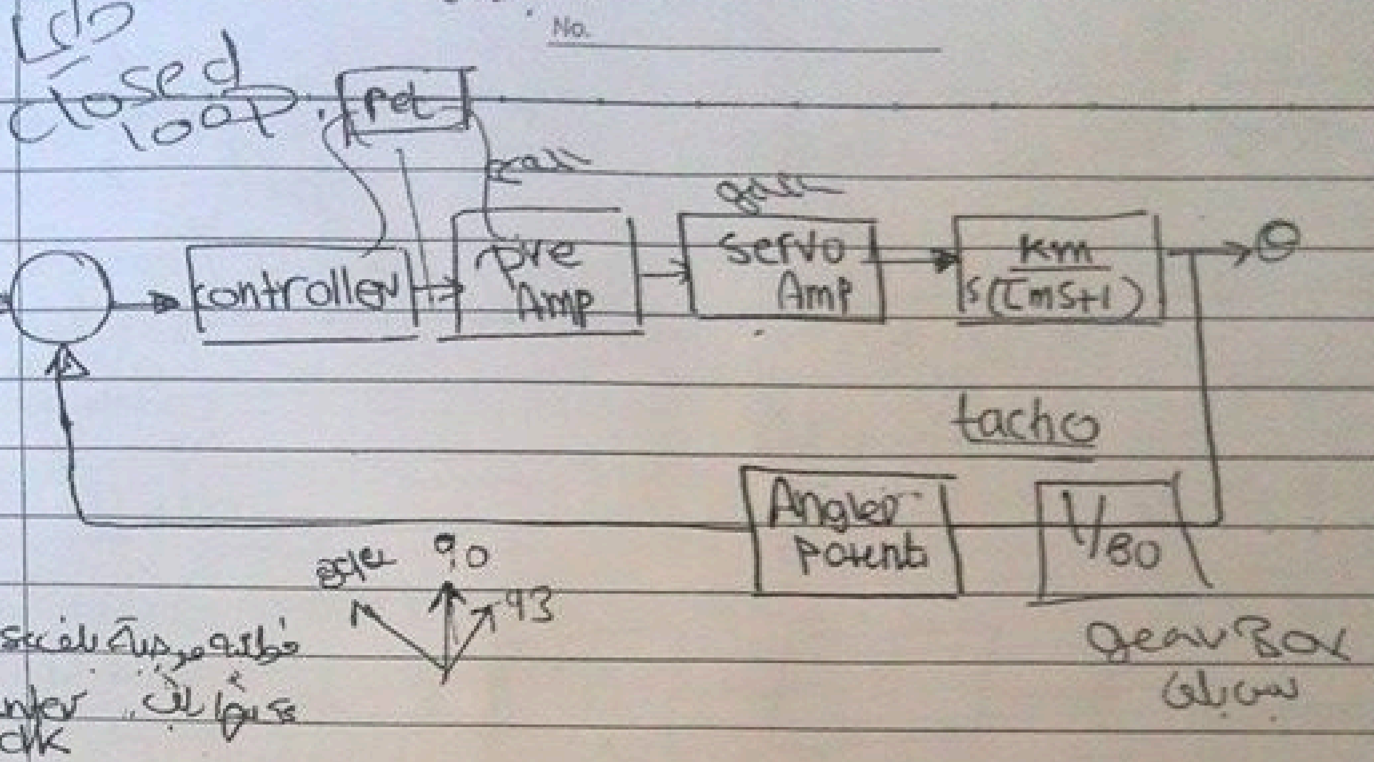


Sensor "code"

[illegible]

No.

closed loop

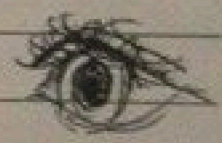


clockwise [illegible]

counter clock [illegible]

PreAmp signal from controller (+ve or negative)

+	H1 L2	CW
-	H2 L1	CCW



open loop [illegible]

unstable

power pre Amplifier

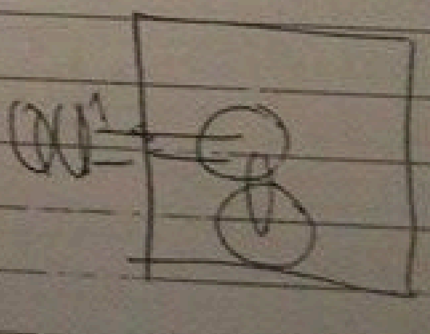
speed [illegible]

Power [illegible] Attenuated

[illegible]

manual

multistage.



No.

zero → K → 0 → ∞

صفر

root locus (matlab)

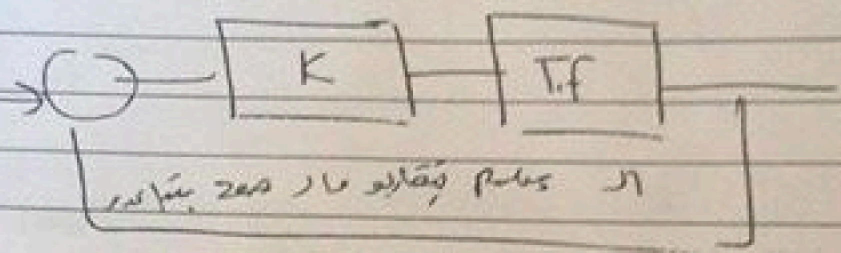
$g = \frac{K}{s^2+3s+2}$ (stable) مافي تغير بالاشارة

$(s+2)(s+1)$

$(-2, -1)$

open

الـ system ما بأثر على stability بأثر على steady state value.



صفر [illegible]

closed loop

بتغير بتغير الـ gain

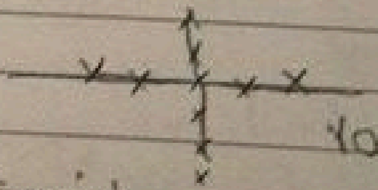
$\frac{K}{s^2+3s+(2+K)}$

K_s

$\phi = \frac{2K+1}{n-m} 180$

قيم الـ system بتتغير من 0 ← ∞ دلالة رسمة

١) نكتب الـ D على صيغة $\Delta(s) = 1 + K\frac{zero^{m}}{poles_{n\times}}$



root locai

٢) نحدد نقاط الـ σ ← $\sigma = \frac{\sum poles - \sum zero}{n-m}$

[illegible] conjugate

٣) من معادلة Ds نكتبها بالشكل القانوني

$\Delta(s) = s^2 + 2\zeta\omega_n s + \omega_n^2$

نطلع ω_n و ζ ونجد s_1 و s_2

ونكتب

$s_{1,2} = -\zeta\omega_n \pm \omega_n\sqrt{\zeta^2-1}$

$K=0, K=1$

$\Delta(s) = s^2 + 3s + (2+K)$

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

$K \frac{1}{s^2+3s+2}$

$|KG(s)| = 1$

$\angle KG(s) = \pi + 2n\pi$

$\phi_A = \frac{2K+1}{n-m} 180, K = 0, 1, \Rightarrow \phi_i = 2K+1$

No.

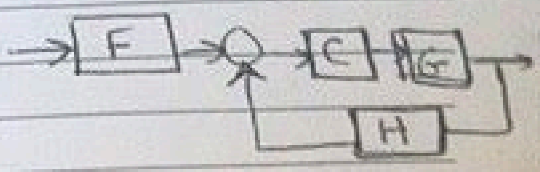
~~g1=tf(1,[1 3 2])~~

بيطلع
window
splane

g1=tf(1, [1 3 2])
rltool

PID

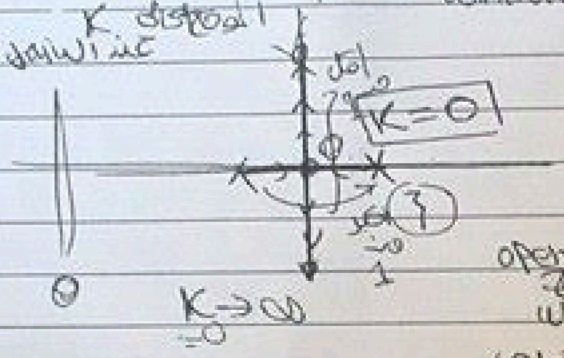
Controller



GUI ⇒
file → Import → G → g1

under damped ~~[illegible]~~ [illegible] في window

K الصفر
عند السالب



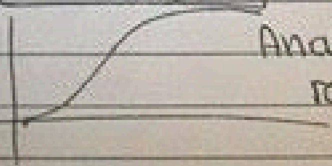
Poles → X
zeros → O

① بنلاقي open loop zeros when K=0

② وبنشوف لوبة بتاعة الرسمة

③ second order system.

overdamped
K=0



Analysis ⇒
response ~~[illegible]~~ step
command.

open loop poles → K=0
اذا حطينا ال poles موجودة zeros

underdamped (Req

No.

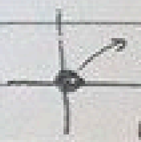
هيك الاسئلة بتجي

① stable or not
② if we change the gain could be unstable?
③ " " " " , overdamped

critically damped — overdamped — under
Repeated — real — عالمحور Imaginary left

critically

كيف بعرف قيم K؟



بزيد قيمة gain بين (0 – 0.25) overdamped ①

عند 0.25 critical ②

0.25 – ∞ underdamped. ③

مش ممكن يكون critically damped [illegible]

بزيد under

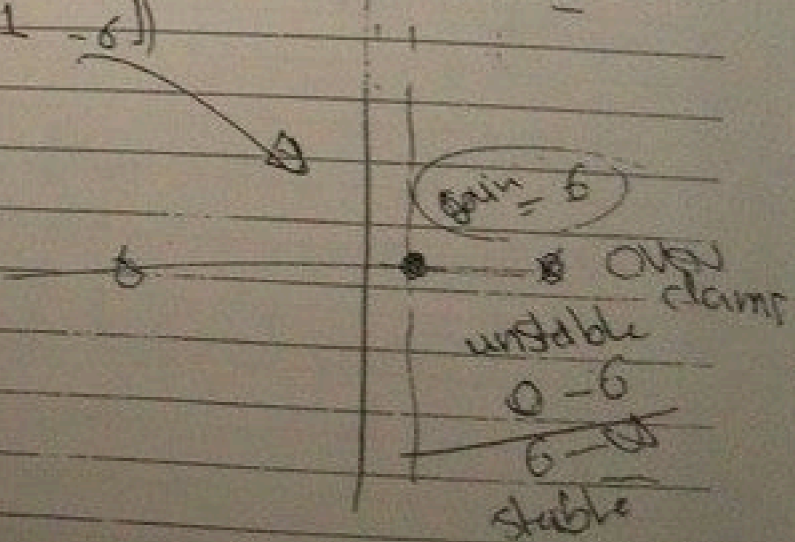
g1 = tf(1, [1 2 3])
file import g

Under damped لحد 36 ~~[illegible]~~ real axis

stable لانو

g3 = tf(1, [1 1 -6])

g4 = tf(1, [1, -6, 5])
unstable لأنه
هو بتعرف قيمة ال K
ما بتعرف شو ما كانت



PID   P → pure K_P

~~pure Kp~~

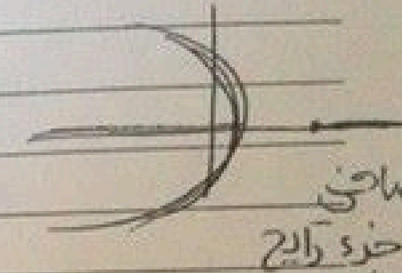
$I \to K_I \frac{1}{s}$ (integrator) → pole

$D \to K_D s$ (differentiator) → zero

$K_P + \frac{K_I}{s} + K_D s$

PI   PD

unstable system نغير ال → stable
صار هيك
(ZJ نضيف pole)(صار تقل إشي)



لما نجي جزء زايد عال the marginal stable

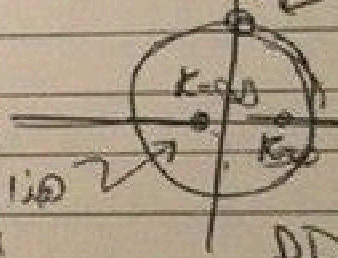
Add real pole ☒

Add real zero ◙

Zero / [illegible]

Stable ← Zero نضيف

صارت هيك



هذا ال zero الي ضفتو

PD controller نعرفه من form $\frac{A}{P} + \frac{BS}{D}$ PD controller

Pole zero cancelation

لما zero يكون فوقه pole

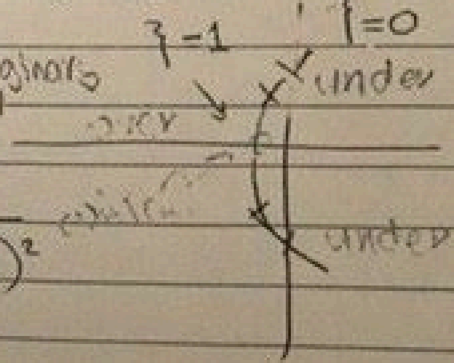
~~complex~~

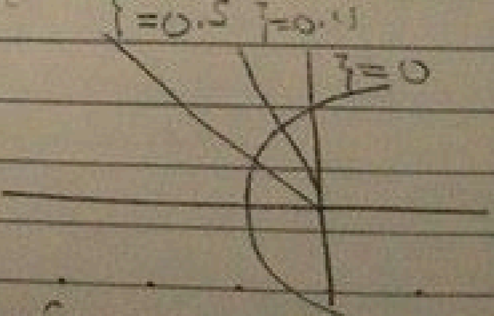
$\overbrace{-\underset{A}{\zeta\omega_n}}^{\text{Real}}\ \overbrace{\mp j\underset{B}{\omega_n}\sqrt{1-\zeta^2}}^{\text{Imaginary}}$

الوتر $= \sqrt{(Img)^2 + (Real)^2}$

$= \omega_n$ ← طول الوتر

$\zeta = \cos^{-1} B$





إذا طلب من الماتلاب يرسم اشي يسوي عالي ζ ثابتة ح يرسم خط

No.

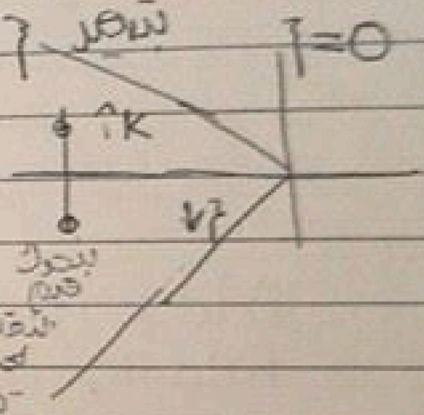
حل عاوز نصف القطر للـ wn لأنها وش)
المكان الهندسي للـ ثابتة تكون (دائرة)

① Right click on S-plane ⇒
② design requirment → new
③ Range المتطلب ح يعطي
للـ ζ و wn

④ OP بنغيرها →

⑤ نرسم خط يمثل ζ

بين منطقة يلتقي بها root locus مع خط ζ



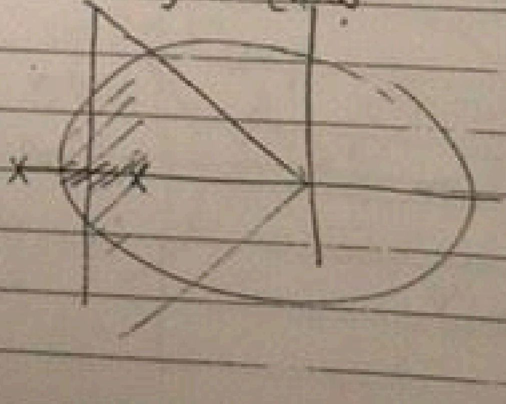
بنحط هنا نقطة عند تقاطع ζ مع خط ζ
بنقرا الـ gain

↑ζ , K↓

تفسير الـ wn natural freq نرسمها

ζ>0.4
wn>1.7

بتطلع دائرة



wn<1.7 برا الدائرة
wn>1.7 جوا الدائرة