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MID exam 8_6_2023 control systems (computer engineering) Prof. M. Barghash IE SoE UoJ

Name Salem elias Bouri ID 0202428

Q1)a)Find the solution of the following differential equation using inverse laplace transform (2 points)

$\ddot{X} + 2X = u(t)$ u(1) is the unity step function

The Laplace Transform

Transform Pairs:

f(t)	F(s)
$\delta(t)$	1
$u(t)$	$\frac{1}{s}$
e^{-st}	$\frac{1}{s+a}$
te^{-at}	$\frac{1}{(s+a)^2}$
$t^n e^{-at}$	$\frac{n!}{(s+a)^{n+1}}$
$\sin(wt)$	$\frac{w}{s^2+w^2}$
$\cos(wt)$	$\frac{s}{s^2+w^2}$

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

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

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

1/2

B) write the laplace code to invesre laplace y(s)= $\frac{1}{s^2+2s+3}$ (2 points)

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syms s,t
ilaplace(1/(s^2+2*s+3))
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2/2

c)what is the final value for y(s) in part y(s)= $\frac{1}{s^2+2s+3}$ (1 points)

$\lim_{s\to 0} sy(s)$

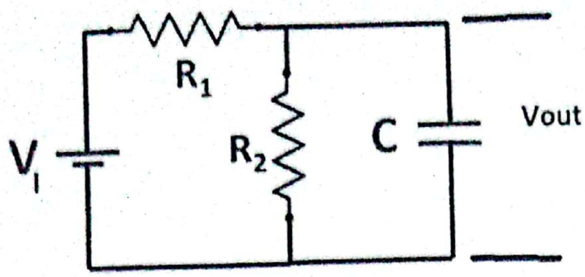
$\frac{s}{s^2+2s+3}$

2/2

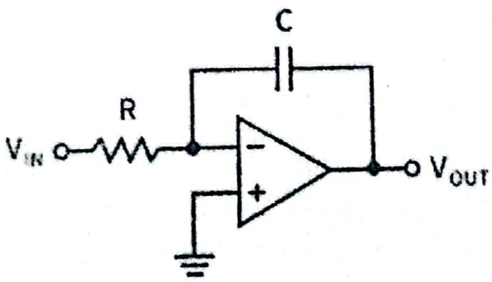
0

$\frac{0}{3} = 0$

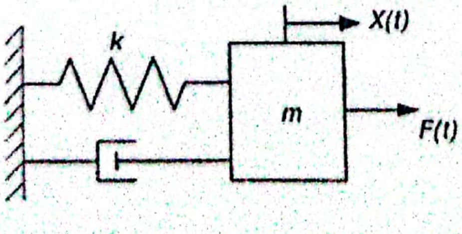
Q2) find the transfer function for the following



a) Vout/Vi (1 points)



b) Vout/Vin (2 points)



c) (damper cofficient =C) X/F (2 points)

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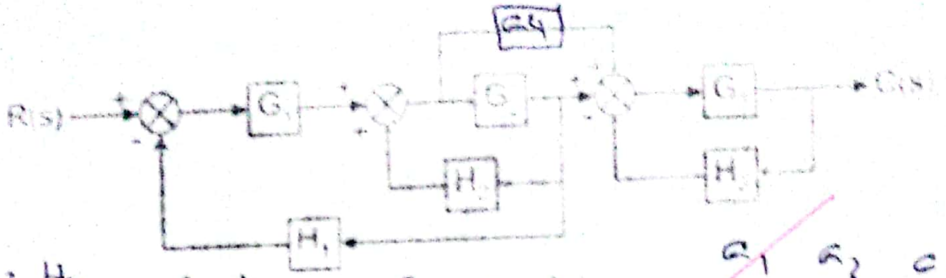
Q3) Find the equivalent transfer function for (5 points)

G4 = 1



Loop: G_2H_2 $\quad -G_3H_3$ $\quad -G_1G_2H_1$

Non touching: $-G_2G_3H_2H_3$ $\quad G_1G_2G_3H_1H_3$

$G_1\ G_2\ G_3$

$G_1\ G_4\ G_3$

$$\frac{G_1G_2G_3 + G_1G_3}{1 - G_2H_2 + G_3H_3 + G_1G_2H_1 - G_2G_3H_2H_3 + G_1G_2G_3H_1H_3}$$

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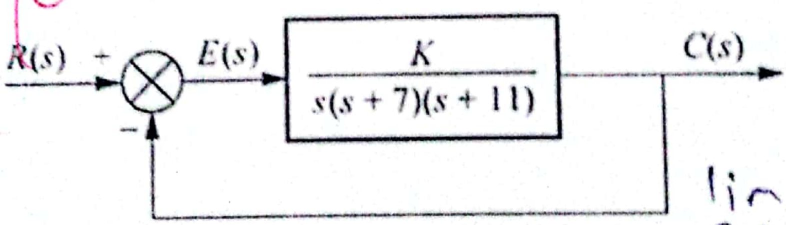
Q4) Find the steady state error for a step input (5 points)



$R = \frac{1}{s}$

$\lim_{s\to 0} sE_s$ $\quad E_s = \frac{R}{1+G(s)}$

$$\lim_{s\to 0} \frac{1}{1+\frac{1}{s(s+7)(s+11)}} = \infty = \frac{1}{\infty} = \boxed{0}$$

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

Final answ

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Q5) a) For the following pole what is the $s=-1+j2$ what is the damping ratio and wn associated with this pole (2.5 points)

$\zeta\omega_n = 1$

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

$\frac{\zeta}{\sqrt{1-\zeta^2}} = \frac{1}{2}$

$\frac{\zeta^2}{1-\zeta^2} = \frac{1}{4} \rightarrow \frac{1}{4} - \frac{1}{4}\zeta^2 = \zeta^2$

$0.447 \times \omega_n = 1$

$\zeta^2 = \frac{1}{5} \leftarrow \frac{5}{4}\zeta^2 = \frac{1}{4}$

$\omega_n = 2.23$

$\zeta = 0.447$ damping ratio

b) what is the percent overshoot for this system to a step input $\frac{1}{s^2+2s+5}$ (2.5 points)

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

$\omega_n = 2.23$

$\zeta = \frac{a}{2\omega_n} = \frac{2}{2 \times 2.23}$

0.448

$mp = 20.73\ \%$

Q6)What is the) a) For the following system $G = \frac{s+12}{(s+10)(s+5)}$, H=1 design the feedback controller k to achieve a damping ratio of > 0.97. (you must use the root locus figure below) (5 points)

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$\cos^{-1} 0.97 = 14$ degree

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

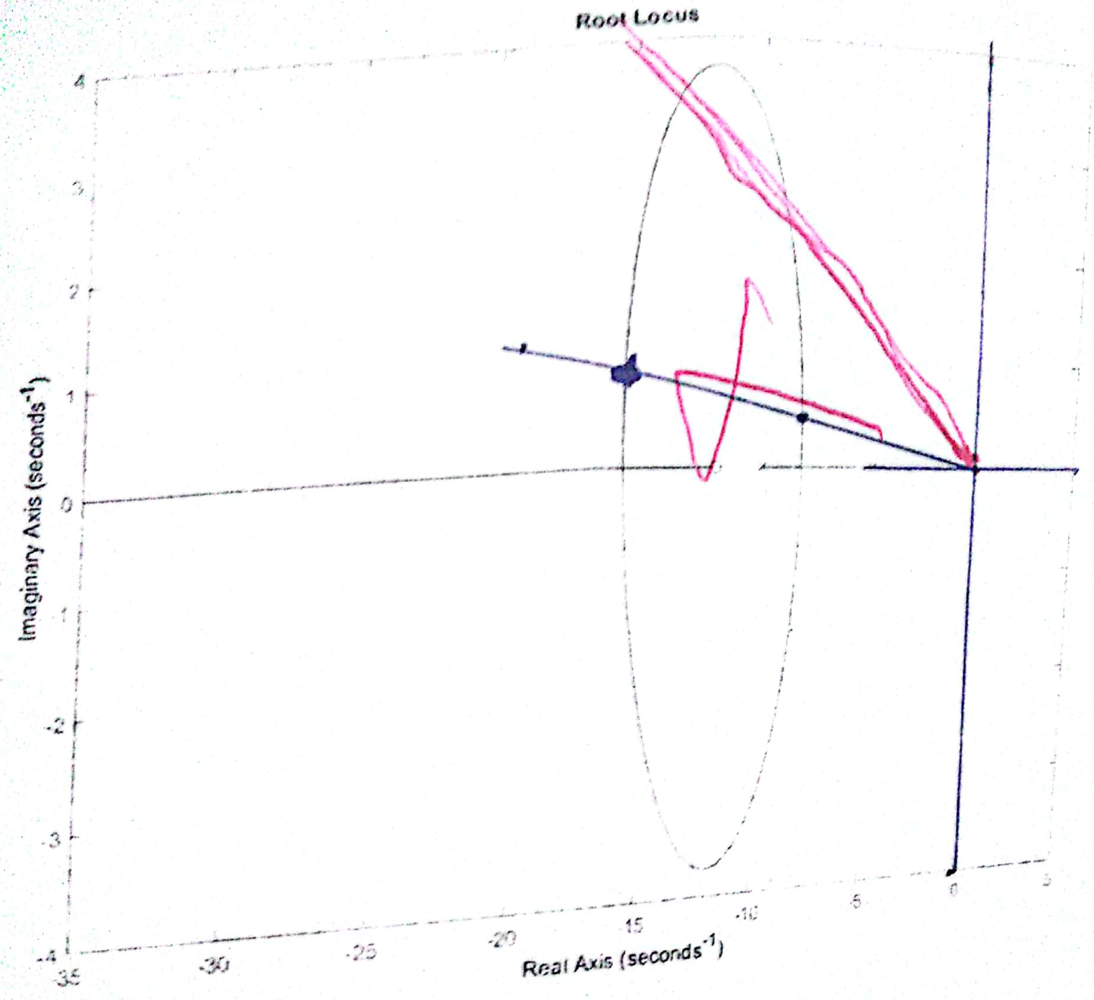
$s_1 = -9 + 0.5j$

$0 < k_1 < 1.483$

$s_2 = -15 + j$

$16.2 < k_2 < 8$

inf


Root Locus
Imaginary Axis (seconds^-1)
Real Axis (seconds^-1)
4
3
2
1
0
-1
-2
-3
-4
-35
-30
-25
-20
-15
-10
-5
0
5

$S = -9 + 0.5j$

$S_2 = -15 + j$