University of Jordan
Elect. Eng. Dept.
First Exam

Control Systems 903441 | Monday 19/6/2017
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Answers should be written in ink | Exam Duration: 50 min

$\boxed{17}$

Q1 a) Consider the following systems with present day design. Classify them as **open loop** or **closed loop** stating the **type of feedback** if the system is closed loop, and **appreciable** parameter variations and external disturbances if applicable . Feel free to express your ideas in **Arabic** if you wish.

dealcargo → fuel / Number of peoples.

System	Open or closed	Type of feedback	Parameter variations	External disturbances
A leaky oil tanker ship controlled by the captain	closed	-ve.	~~fast winds~~ ~~High waves~~ ~~Dark clouds~~	fast winds. High waves. very Dark clouds.
Dish Washer جلاية الصحون	open.	—	decreasing in the wed water.	~~Dirts~~ cutting in the electrical source.

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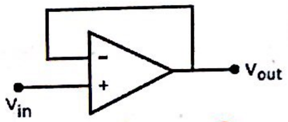
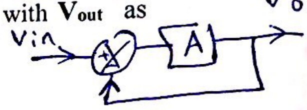
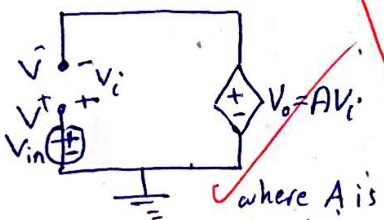
b) i) Consider the op-amp circuit shown. Use the ideal op-amp model with $R_i = \infty\ \Omega$, and $R_o = 0\ \Omega$ to obtain a block diagram **involving feedback** with **Vout** as output, and **Vin** as set value.



OR



Model would be as follows:



where A is the gain.

By KVL:

$-V_{in} + \frac{V_o}{A} + V_o = 0$

so $\boxed{V_o = V_{in} - \frac{V_o}{A}}$

The BD as follows:

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ii) Write down the value of $S_k^{1/N}$ in terms of S_k^N . Hence for a particular N , if k undergoes a decrease by **10%** , what percentage change $1/N$ undergoes?. Physically , what does that change mean

$S_K^{\frac{1}{N}} = \frac{K}{\frac{1}{N}} \frac{d(\frac{1}{N})}{dK}$

$= KN\left(\frac{-\frac{dN}{dK}}{N^2}\right)$

$= \frac{-K}{N}\frac{dN}{dK} \Rightarrow \boxed{S_K^{\frac{1}{N}} = -S_K^N}$

since $S_K^{\frac{1}{N}} = -S_K^N$

for sensitivity we care for $|S_K^{\frac{1}{N}}| = |S_K^N|$

so the change for $\frac{1}{N}$ would be 10%.

$\Rightarrow$ physically, it means ~~in~~sensitive. 2

c) a system is given by the following transfer function $G(s) = \frac{100}{2s^2 + 12s + 50}$. Using **any method** , determine the system output response due to a **unit step** input. Hence, or otherwise, what is the **unit impulse** response

$G(s) = \frac{50}{s^2 + 6s + 25}$

case(1): $R(s) = \frac{1}{s}$.

so $C(s) = \frac{50}{s(s^2+6s+25)}$

$= \frac{A}{s} + \frac{Bs + D}{s^2+6s+25}$

$s^2+6s+25 \to (s+3)^2 + 16$

using partial fraction you can find that:

$\boxed{A = 2}, \boxed{B = -2}, \boxed{D = -12}$

Take Inverse LT:

$c(t) = [2 - 2e^{-3t}\cos 4t - \frac{6}{4}e^{-3t}\sin 4t]u(t)$,

case(2): $C(s) = \frac{50 \times 1}{s^2(s^2+6s+25)}$

$= \frac{A}{s^2} + \frac{B}{s} + \frac{Ds + F}{s^2+6s+25}$

solving: $\boxed{A = 2}$, $\boxed{B = \frac{-25}{12}}$, $\boxed{D = \frac{25}{12}}$

$\boxed{F = \frac{21}{2}}$

$c(t) = [2t + \frac{-25}{12} + \frac{25}{12}e^{-3t}\cos 4t + \frac{51}{(12)(4)}e^{-3t}\sin 4t]u(t)$.

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Q2 a) A system is given by the following differential equations

$$\frac{dx}{dt} = -2x + 2h \quad \text{and} \quad \frac{dh}{dt} = -x - 5h + 24r(t)$$

Feel free to use any method to solve for $x(t)$ when $r(t)$ is a **unit ramp**.

$r(t) = t\,u(t)$

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

Take LT:

$sX = -2X + 2H$

$sH = -X - 5H + \frac{24}{s^2}$

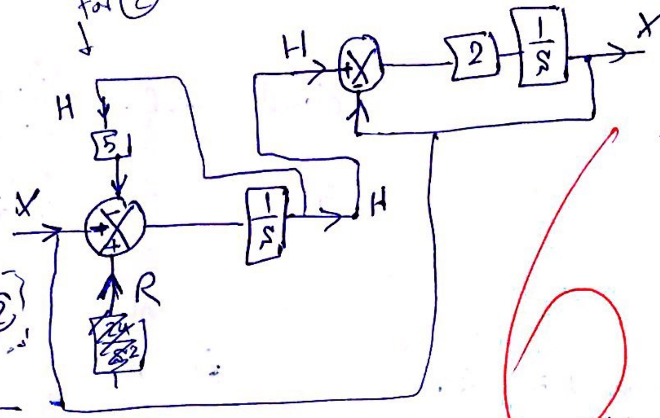
Rearrange:

$X = \frac{1}{s}[-2X + 2H]$ -- ①

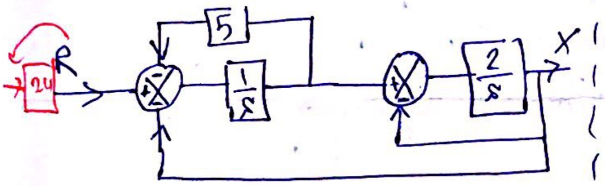
$H = \frac{1}{s}[-X - 5H + \frac{24}{s^2}]$ -- ②, with $\frac{24}{s^2}$ = R

obtaining a BD:

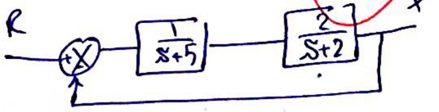
for ② for ①

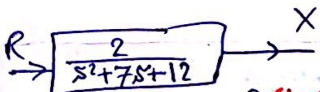


More Neat Diagram:



Now we have to reduce it as we learned:





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

so $X = \frac{2 \cdot 48}{s^2(s+3)(s+4)}$

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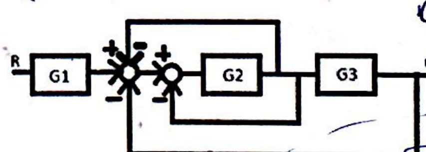
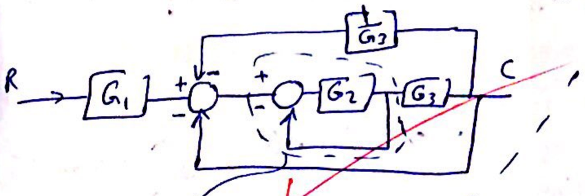
by partial fraction:

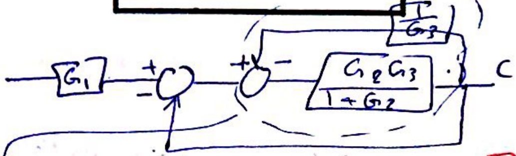
$x(t) = (At + B + Ce^{-3t} + De^{-4t})u(t)$

where $A = \frac{1}{6}$, $C = \frac{2}{9}$, $D = \frac{-1}{8}$

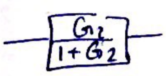
b) Use **block diagram reduction techniques** to obtain $\frac{C}{R}$







Basic FB



cascaded with G_2

$$\frac{G_2G_3/1+G_2}{1 + \frac{G_2G_3}{1+G_2} \cdot \frac{1}{G_3}} = \boxed{\frac{G_2G_3}{1+G_2+G_2}}$$

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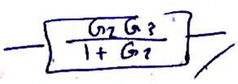
Basic FB with 1 then cascaded with G_1



$$\frac{\frac{G_2G_3}{1+2G_2}}{\frac{G_2G_3}{1+2G_2} + 1} = \boxed{\frac{G_2G_3}{1+2G_2+G_2G_3}} * G_1$$

final Reduction = $\frac{G_1G_2G_3}{1+2G_2+G_2G_3}$ #