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Subject - control system
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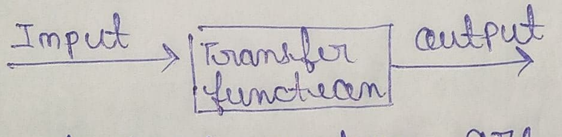
Group - A

1. (a) A transfer function represents the relationship between the output signal of a control system and the input signal, for all possible input values. A block diagram is visualization of the control system which uses blocks to represent the transfer function, and arrows which represent the various input and output signals.

For any control system, there exists a reference input known as excitation or cause which operates through a transfer operation to produce an effect resulting in controlled output or response



1. (b) closed loop system are accurate and reliable than the open loop system and the changes in output due to external disturbances are corrected automatically.

1. (c) Any physical system which does not automatically correct the variation in its output is called an open loop control system. The conventional electrical washing machine is an example of open-loop system because

the wash time is set by the estimation of the human operator, not on the basis of whether the clothes are clean properly.

1. (d) Poles and zero of the transfer function are the frequencies for which the value of the ~~dem~~ denominator and numerator of transfer function becomes zero respectively. The values of poles and zeros of a system determines whether the system is stable, and how well it performs.

1. (e) MIMO system stands for Multiple Inputs and Multiple output system. They have more than one input and more than one output.

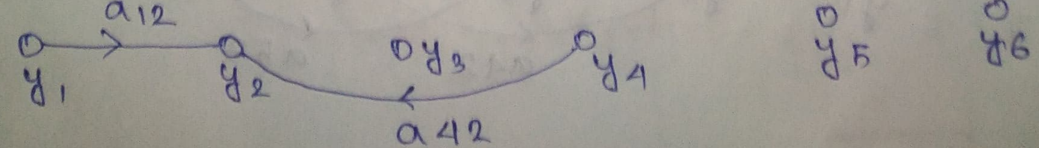
Group - B

3.
$$y_2 = a_{12} y_1 + a_{42} y_4$$
$$y_3 = a_{23} y_2 + a_{53} y_5$$
$$y_4 = a_{34} y_3$$
$$y_5 = a_{45} y_4 + a_{35} y_3$$
$$y_6 = a_{56} y_5$$

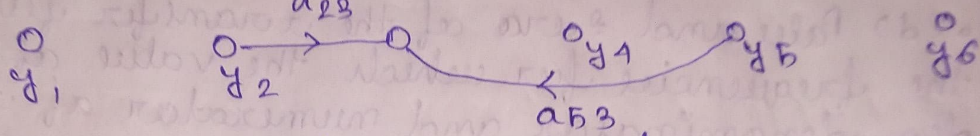
Construction of Signal Flow Graph :

There will be six nodes (y_1, y_2, y_3, y_4, y_5 and y_6) and eight branches in signal flow graph. The gains of the branches are a_{12}, a_{23}, a_{34}, a_{45}, a_{42}, and a_{35}.

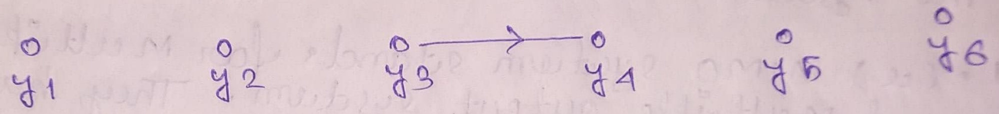
Step 1



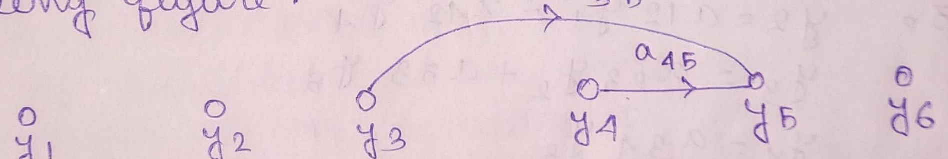
Step 2: Signal flow graph for $y_3 = a_{23} y_2 + a_{53} y_5$ is shown in the following figure.



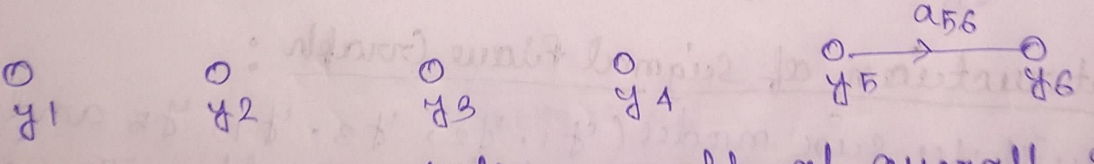
Step 3: signal flow graph for $y_4 = a_{34} y_3$ is shown the following figure.



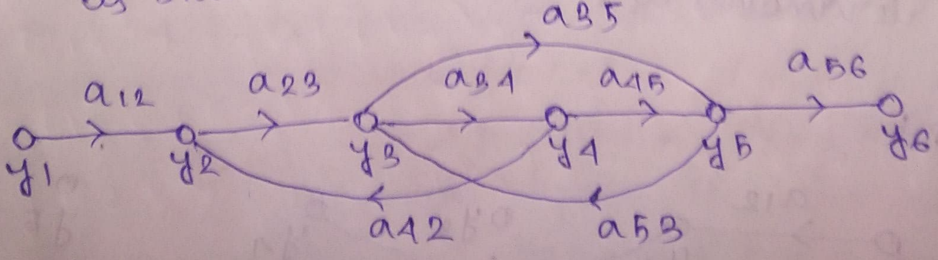
Step 4: signal flow graph for $y_5 = a_{45} y_4 + a_{35} y_3$ is shown in the following figure.



Step 5: signal flow graph for $y_6 = a_{56} y_5$ is shown in following figure.



Step 6: signal flow graph of overall system is shown in the following system.



5. Transfer function $= \dfrac{G(s)}{1+G(s)H(s)}$

$$= \dfrac{\dfrac{16}{s^2+4s+16}}{1+\dfrac{16}{s^2+4s+16}\cdot Ks}$$

$$= \dfrac{16}{s^2+(4+16K)s+16}$$

Here, $\omega_n^2 = 16$

$\Rightarrow \omega_n = 4$

and

$2\xi\omega_n = 4+16K$

$\Rightarrow 2\times0.8\times4 = 4+16K$

$K = 0.15$

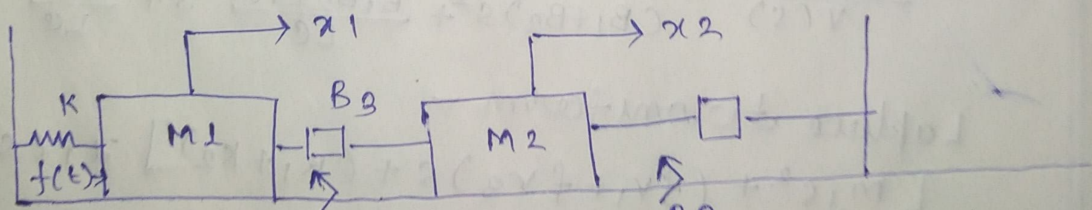
$\therefore$ transfer function is

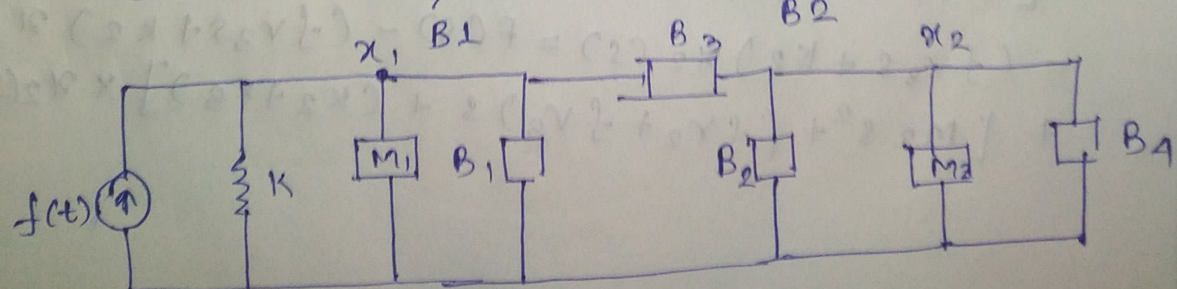
$$\dfrac{C(s)}{R(s)} = \dfrac{16}{s^2+6.4s+16}$$

Peak overshoot, $M_p = e^{\frac{-\pi\times0.8}{\sqrt{1-0.8^2}}}$

$= 0.015$

2.





multiple loops are present
B_1, B_2 are current in negative direction

$$\frac{f(t) - v(x_1)}{K} - \frac{v(x_1)}{B_1} + \frac{v(x_1) - v(x_2)}{B_2} = 0$$

$$\Rightarrow \frac{f(t) - v(x_1)}{K} - \frac{v(x_1)}{db_1/dt} + \frac{v(x_1) - v(x_2)}{db_2/dt}$$

Rearranging and expressing the resistances as conductance, $B_1 = 1/K$ and $B_2 = 1/K$,

we obtain,

$$(B_1 + B_2 + \frac{1}{K}) v_L(x_1) - B_2 v_c(x_2) = B_1 v(x_1)$$

$$- B_2 v_1(x_1) + (B_2 + x_2) v_c(x_1) = 0$$

solving the transfer function $\frac{v_c(x_1)}{v(x_1)}$ yields

$$= \frac{v_c(x_1)}{v(x_1)} = \frac{\frac{B_1 B_2}{C} x_1}{(B_1 + B_2) x_1^2 + \frac{B_1 B_2 L + C}{LC} x_1 + G_2/LC}$$

$$\frac{v_c(s)}{v(s)} = \frac{\frac{B_1 B_2}{C} s}{(B_1 + B_2) s^2 + \frac{B_1 B_2 L + C}{LC} s + \frac{B_2}{LC}}$$

Laplace transform -

$$[M_1 s^2 + (f v_1 + f v_3) s + (K_1 + K_2)] x_1(s)$$

$$- (f v_3 s + K_2) x_2(s) = F(s) - (f v_3 s + K_2) x_1(s)$$

$$+ [M_2 s^2 + (f v_2 + f v_3) s + (K_2 + K_3)] \times x_2(s) = 0$$

transfer function $= \dfrac{x_2(s)}{F(s)}$ is

$$\frac{x_2(s)}{f(s)} = G(s) = \frac{(f_{v3}\,s + K_2)}{\Delta}$$

$$\Delta = \begin{vmatrix} [M_1 s^2 + (f_{v1} + f_{v3})s + (K_1 + K_2)] & -(f_{v3}s + K_2) \\ -(f_{v3}s + K_2) & [M_2 s^2 (f_{v2} + f_{v3})s + (K_2 + K_3)] \end{vmatrix}$$