MATHEMATICAL MODELS AND BLOCK DIAGRAMS

WEBSITE takes you to the Start Page after you have read this Chapter.
Start Page has links to other Chapters

Problem 1 Matrices and differential equations

(a) Find matrices X and Y such that AX =B and YA=B where

$$A = \begin{Bmatrix} 2 & -1 \\ -3 & 2 \end{Bmatrix}, \qquad B = \begin{Bmatrix} 3 & 2 \\ -6 & -5 \end{Bmatrix}$$

(b) Determine the solution of the following set of first-order coupled differential equations:

$dx_1/dt = x_2$
$dx_2/dt = -6x_1 - 5x_2$

when the initial conditions are $x_1(0) = 1$ and $x_2(0) = 0$.

Solution

(a)

$$X = \begin{Bmatrix} 0 & -1 \\ -3 & -4 \end{Bmatrix}$$

$$Y = \begin{pmatrix} 12 & 7 \\ -27 & -16 \end{pmatrix}$$

(b)

Answer:

$x_1 = 3e^{-2t} - 2e^{-3t}$
$x_2 = -6(e^{-2t} - e^{-3t})$

TOP

Problem 2 Solution of second-order differential equation

(a) Determine the solution of the following differential equation when all the initial conditions{i.e. y(0) and $dy/dt\,|_0$ }are zero and f(t) = 4t:

$$d^2y/dt^2 + 3\,dy/dt + 2y = f(t)$$

(b) Determine the inverse transformation of the following transformed equation:

$$Y(s) = 75/\,[s^2 + 4s + 13)\,(s + 6)]$$

Solution

(a)

Answer: $y = 4e^{-t} - e^{-2t} + 2t - 3$

(b)

Answer: $y = e^{-2t}\,(4\sin 3t - 3\cos 3t) + 3e^{-6t}$

Or: $y = 3e^{-2t}\sin(3t - 36.9^0) + 3e^{-6t}$

TOP

Problem 3 Partial fraction expansions

Find the partial fraction expansions of the following algebraic fractions:

(a) $F(x) = \dfrac{2(x^2+3x+1)}{x(x^2+3x+2)}$

(b) $F(x) = \dfrac{2x+3}{(x+1)(x2+4x+5)}$

(c) $F(x) = 1/[x^2(x+1)]$

Solution

(a) Answer: $(1/x) - (2/(x+1)) - (1/(x+2))$
(b) Answer: $[(0.25+j.75)/(x+2+j1)] + [(-0.25-j.75)/(x+2-j1)] + 0.5/(x+1)$
(c) Answer: $(1/x^2) - (1/x) + (1/(x+1))$

TOP

Problem 4 Determinant, inverse and eigenvalues of a matrix

(a) Find the determinant and inverse of the following matrix.

$$A = \begin{pmatrix} -2 & 3 & 1 \\ 4 & 6 & -2 \\ 8 & 4 & 1 \end{pmatrix}$$

(b) Find the eigenvalues of the following matrix.

$$B = \begin{pmatrix} -2 & -5 & -5 \\ 1 & -1 & 0 \\ 0 & 1 & 0 \end{pmatrix}$$

(c) Find exp (-Ct) for the following matrix.

$$C = \begin{pmatrix} 0 & 1 \\ -2 & -3 \end{pmatrix},$$

Solution

(a) Determinant of A = -120

$$\text{Inverse of } A = -(1/120)\begin{pmatrix} 14 & -1 & -12 \\ -20 & 10 & 0 \\ -32 & -32 & -24 \end{pmatrix}$$

(b) Eigenvalues of B = = -1, -1+j2, -1-j2

(c) $\exp(Ct) = L^{-1}[(sI-C)^{-1}]$

$$sI - C = \begin{pmatrix} s & -1 \\ 2 & s+3 \end{pmatrix}$$

$$(sI-C)^{-1} = (1/(s^2+3s+2)).\begin{pmatrix} s+3 & 1 \\ -2 & s \end{pmatrix}$$

$$= \begin{pmatrix} [2/(s+1)] - [2/(s+2)] & [1/(s+1)] - [1/(s+2)] \\ [2/(s+2)] - [2/(s+1)] & [2/(s+2)] - [1/(s+1)] \end{pmatrix}$$

$\exp(Ct) = L^{-1}[(sI-C)^{-1}] =$

$$= \begin{pmatrix} 2e^{-t} - e^{-2t} & e^{-t} - e^{-2t} \\ 2e^{-2t} - 2e^{-t} & 2e^{-2t} - e^{-t} \end{pmatrix}$$

TOP

Problem 5 Solution of first-order coupled differential equations

(a) Describe a procedure to solve a set of first order coupled differential equations

(b) Solve the following system of linear differential equations with constant coefficients:

$$3\frac{dx_1}{dt} + 2x_1 + \frac{dx2}{dt} = 1 \qquad t \geq 0$$

$$\frac{dx_1}{dt} + 3x_2 + 4\frac{dx_2}{dt} = 0$$

The initial conditions are:

$$\left.\begin{array}{l} x_1 = 0 \\ x_2 = 0 \end{array}\right\} \quad \text{at} \quad t = 0$$

Solution

(b) Let L-Transform of X1 =Y1

Let L-Transform of X2 =Y2

Transform the differential equations to

(3s+2) Y1 +sY2 =1

sY1 + (4s+3) Y2=0

Solve these two equations to obtain

Y1 = (4s+3)/(s+1) (11s+6) = L (X1)

Partial fractions and Laplace inverse gives

X1 $=0.5-0.2e^{-t} - 0.3\, e^{-6t/11}$

Similarly,

X2 $= 0.5(e^{-t} - e^{-6t/11})$

TOP

Problem 6 **Transfer function of a multiloop feedback control system**

(a) Fig. 1 shows a multiple loop feedback control system.

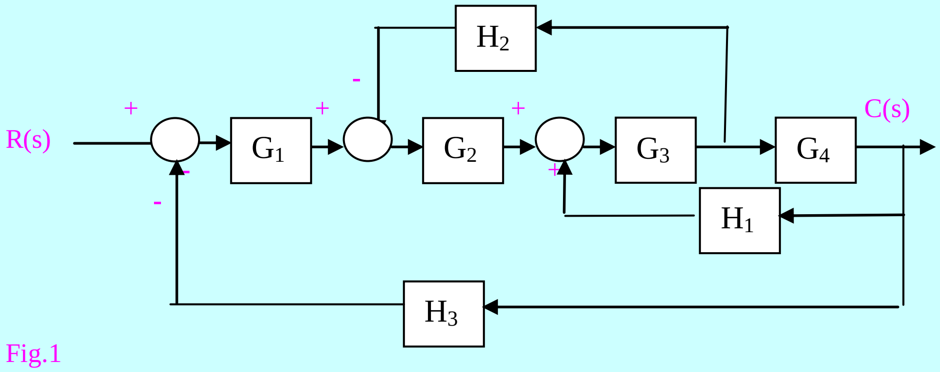
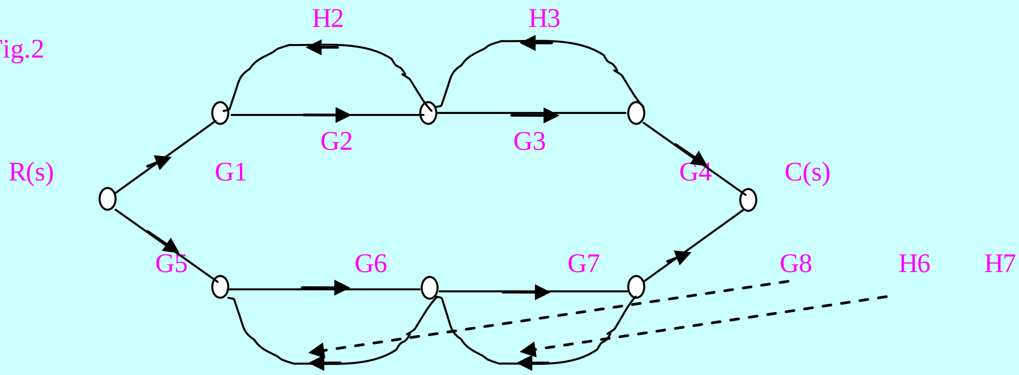


Fig.1

Determine the transfer function of the system, C(s)/R(s), when
$G_1 = G_2 = G_3 = G_4 = 1$, and $H1 = H_2 = H_3 = 1/s$.

(b) Fig.2 shows a two-path signal–flow graph of a multi-legged robot.

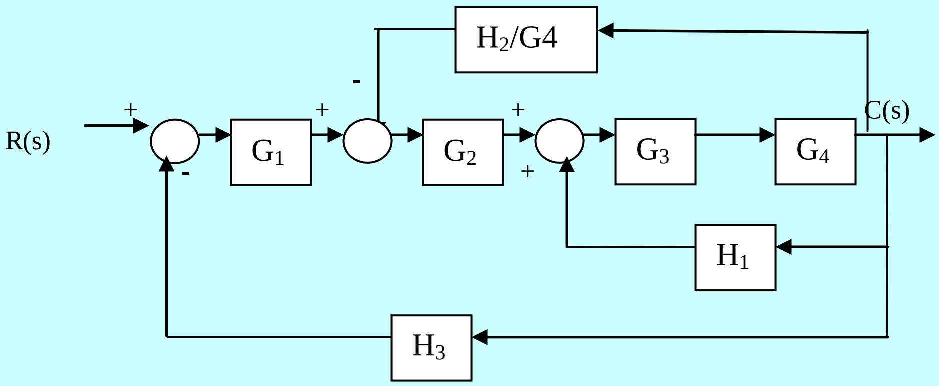
Fig.2

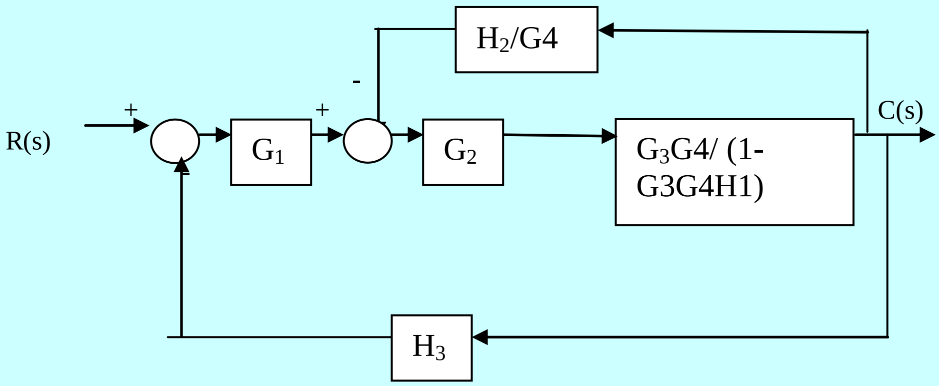


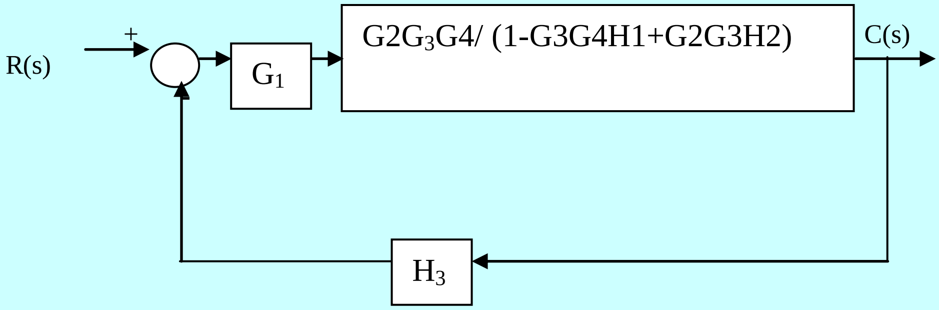
Use Mason’s loop rule to determine the transfer function, C(s)/R(s).

Solution

(a) Using block diagram reduction of the system, we get







Transfer function=C(s)/R(s) = s/(s+1) Ans.

(b) path1: $P1 = G1G2G3G4$

Path2: $P2 = G5G6G7G8$

Self-loops: $L1=G2H2$, $L2 = G3H3$, $L3 = G6H6$, $L4 = G7H7$

Determinant, $\Delta = 1 - (L1+L2+L3+L4) - (L1L3+L1L4+L2L3+L2L4)$

Co-factors: $\Delta1 = 1-(L3+L4)$, $\Delta2 = 1-(L1+L2)$,

$C(s)/R(s) = (P1\Delta1+P2\Delta2)/\Delta$

$=[G1G2G3G4(1-L1-L4)+G5G6G7G8(1-L1-L2)]/(1-L1-L2-L3-L4+L1L3+L1L4+L2L3+L2L4)$

TOP

Problem 7 Feedback model of a system

(a) The student–teacher learning process is inherently a feedback process intended to reduce the system error to a minimum.
The desired input is the knowledge being studied and the student may be considered the process. With the aid of Fig. 3,
construct a feedback model of the learning process and identify each block of the system.

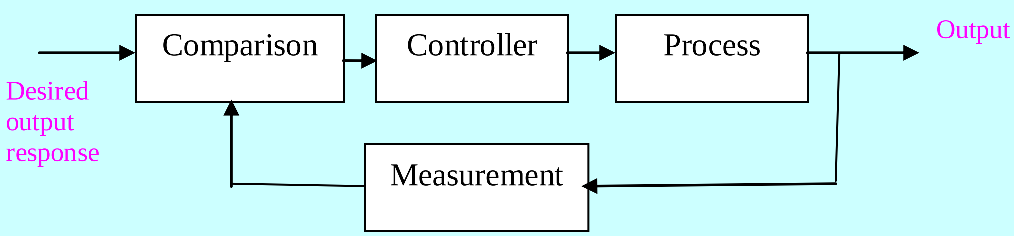


Fig.3

(b) Consider the pendulum of Fig.4. The torque on the mass is

$T = MgL\sin\theta$

where g is the gravity constant. The equilibrium condition for the mass is $\theta_0 = 0^0$. Determine, from first principles, the linear approximation of the nonlinear relation between T and θ. State the range of θ for which the approximation is reasonably accurate.

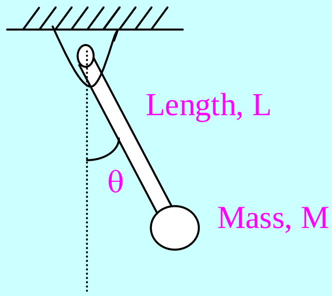
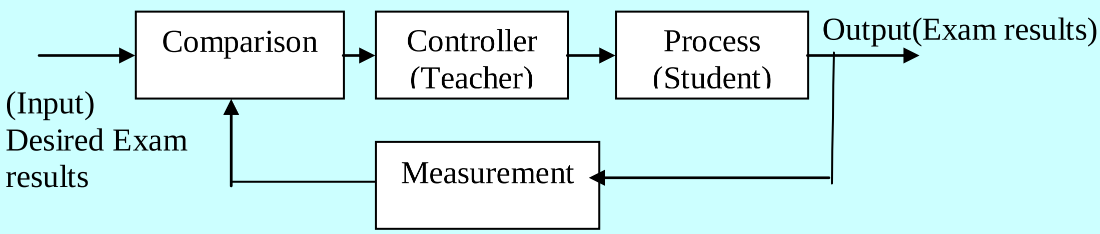


Fig.4

Solution

(a)



(b) $$T = MgL \left.\frac{\delta \operatorname{Sin}\theta}{\delta\theta}\right|_{\theta = \theta_0} (\theta - \theta_0)$$

$= MgL\ (\cos 0^o)\ (\theta - 0^o)$

$= MgL\theta$

This approximation is reasonably accurate for $-\pi/4 \leq \theta \leq \pi/4$.

TOP

Problem 8 Difference equation of a system

(a) Fig.5 shows a mechanical system, where

F (t) =Force applied to the system
M= Mass
B= Coefficient of friction
K= Spring constant
y= Displacement of the mass.

Write the state equations of the system, choosing displacement and velocity of the mass as state variables, x_1 and x_2, respectively.

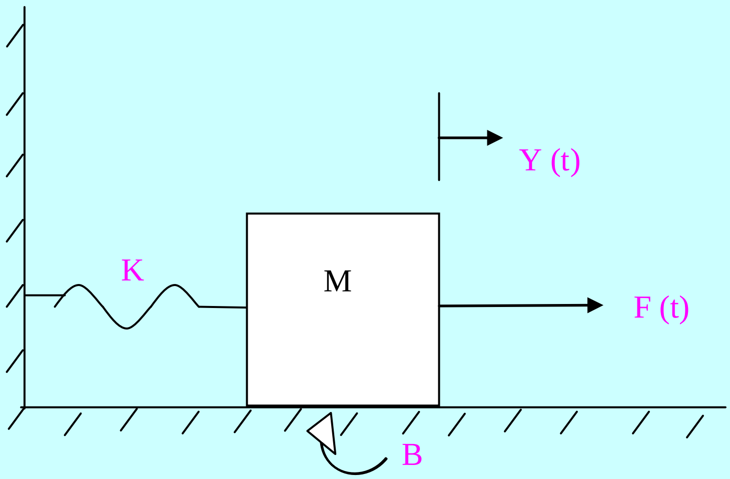


Fig.5

(b) Write the difference equation obeyed by a sum of money in a bank account at a yearly interest rate of R percent, compounded every T years. Denote the amount immediately following the kth interest period as A (kT). Find the differential equation which results as T 0.

Solution

(a) Force absorbed by mass, $f_M = Md^2y/dt^2$

Force absorbed by friction, $f_B = Bdy/dt$

Force absorbed by spring, $fs = Ky$

$f_{M+}\ f_{B\ +}\ f_{s\ =}F$

Let x1 = y, x2= dy/dt

The state equations are:

dx1/dt = x2

dx2/dt = -Kx1/M –Bx2/M +F (t)/M

(b) The principal obeys the difference equation

A (kT+T) =A (kT) [1+RT/100].

Re-writing, [A (kT+T)-A (kT)]/T =RA (kT)/100.

Taking the limit as T $\longrightarrow$ 0 and letting kT $\rightarrow$ t gives the differential equation

dA/dt =RA (t)/100.

TOP

Problem 9 **Controller for a multiloop unity feedback control system**

Fig.6 shows a closed-loop multivariable control system.

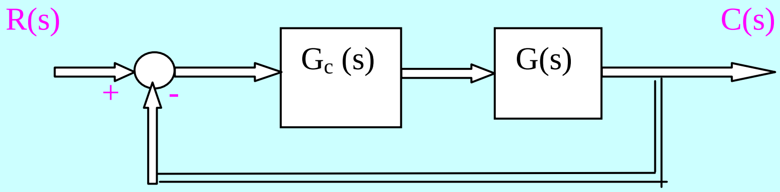


Fig.6

The transfer function for the plant is

$$G(s) = \begin{bmatrix} \frac{5}{1+2s} & \frac{50}{1+2s} \\ \frac{1}{1+s} & \frac{-10}{1+s} \end{bmatrix}$$

The desired closed-loop transfer function is

$$T(s) = \begin{bmatrix} \frac{1}{1+0.5s} & 0 \\ 0 & \frac{1}{1+0.2s} \end{bmatrix}$$

Determine the required controller $G_c(s)$.

Solution

It can be easily shown that $Gc(s) = G^{-1} (T^{-1}-1)^{-1}$

$$(T^{-1}-1) = \begin{pmatrix} .5s & 0 \\ 0 & .2s \end{pmatrix}$$

$$(T^{-1}-1)^{-1} = \begin{pmatrix} 2/s & 0 \\ 0 & 5/s \end{pmatrix}$$

$$G^{-1} = (1/\Delta)\begin{pmatrix} -10/(1+2s) & -50/(1+2s) \\ -1/(1+s) & 5/(1+s) \end{pmatrix}$$

where $\Delta = -100/(1+2s)(1+s)$

$$\text{Therefore, } Gc = \begin{pmatrix} \dfrac{0.2(1+2s)}{s} & \dfrac{2.5(1+s)}{s} \\ \dfrac{0.02\ (1+2s0}{s} & \dfrac{-0.25(1+s)}{s} \end{pmatrix}$$

TOP

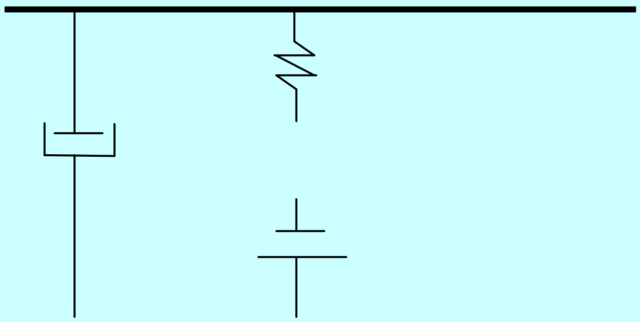
Problem 10 Transfer function of a two –mass mechanical system

(a) Show that a system, which gives a response x corresponding to an input u, and governed by the equation

$u = d^2x/dt^2 + a.dx/dt + b.x$

is linear. Here a and b are constants,

(b) Fig.7 shows a two-mass mechanical system.



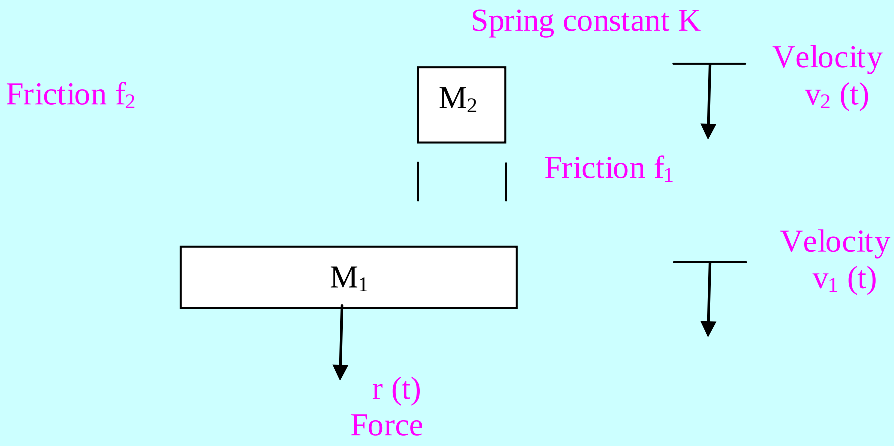

Spring constant K
Friction f_2
M_2
Velocity
v_2 (t)
Friction f_1
Velocity
v_1 (t)
M_1
r (t)
Force

Fig.7

i Determine the transfer function, $V_1(s)/R(s)$, if the velocity of mass M_1 is the output variable and the applied force on M_1 is the input variable.

ii What would be the transfer function when the position $x_1(t)$ of mass M_1 is the output variable?

Solution

(a) $x= [d2/dt^2 +a.d/dt +b]^{-1} .u =T.u$, where T is the system operator.

Multiply both sides of the given equation by a scalar quantity k. We have

$k.u = k\, d^2x/dt^2 +k.a.dx/dt +k.bx$

$= d^2 (kx)/dt^2 +a.d (kx)/dt +b (kx)$

Thus, if x is the response of the system due to an input u, then for an input ku, the response will be kx. Also, let x1 be the

response to u1, and x2 be the response to input u2, then

$u1 = d^2x1/dt^2 +adx1/dt +bx1$

$u2 = d^2x2/dt^2 +adx2/dt +bx2$

Adding the two equations

$u1+u2 = d^2(x1+x2)/dt^2 +ad(x1+x2)/dt +b(x1+x2)$

Thus when, x1=T.u1 and x2 =T.u2,

(x1+x2)=T. (u1+u2) =Tu1+Tu2

Therefore, the system operator is linear.

(c) (i) The simultaneous equations, assuming the initial conditions are zero, are

$M_1s\, V_1(s) + (f_1+f_2)\, V1(s) –f_1V_2(s) +R(s)$

$M_2s\, V_2(s) + f_1\, (V_2(s) –V_1(s)) + KV_2(s)/s=0$

Solve the above two equations for $V_1(s)$ [by eliminating $V_2(s)$] and obtain the transfer function

$$G(s) = V_1(s)/R(s) = \frac{(M_2s^2+f_1s+K)}{(M_1s+f_1+f_2)(M_2s^2+f_1s+K)}$$

(ii) $X_1(s)/R(s) = V_1(s)/sR(s) = G(s)/s$

TOP

Problem 11 Signal-flow graph for a water level controller

(a) Fig.8 shows a water level controller in which the input valve closes completely when the level of water in the tank reaches a height h_r.

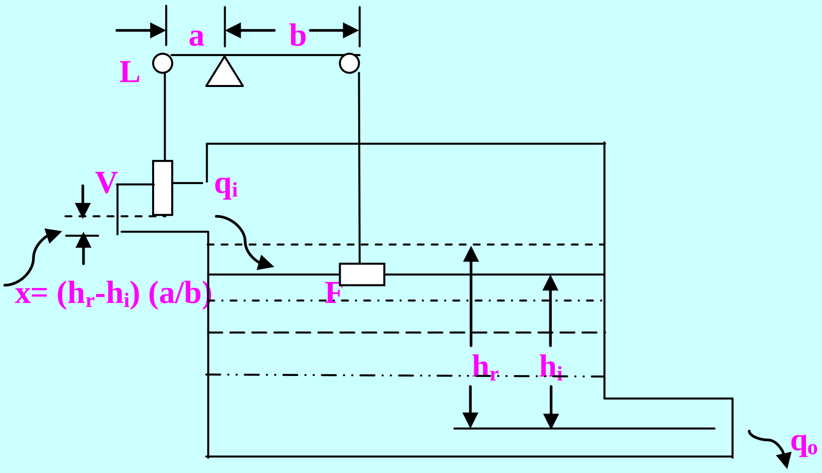


Fig.8

The water level in the tank at any time is h and the valve gate-opening x is caused by the arrangement of the float F and lever L. The cross-sectional area of the tank is A. The valve discharge q_i is proportional to the gate-opening x with proportionality factor k, and the output

flow q_o is proportional to the head h with proportionality factor B. Assume that the maximum input $q_{i, max}$ corresponding to the full gate opening never exceeds the output q_o.
Develop a signal flow graph between the input q_i and the output h_i. Assume that the Laplace transforms of q_i, x, h_r, and h_i are Qi, X, H_r, and H_i respectively.

(b)Determine the transfer function, C/R, for the control system shown in Fig.9.

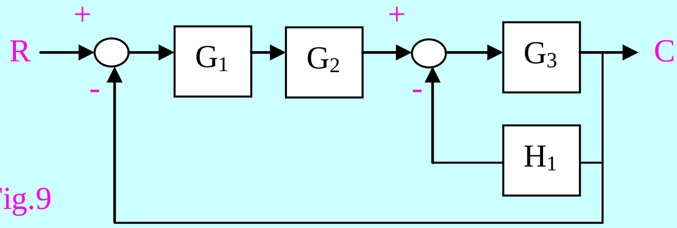


Fig.9

Solution

(a) (i) $qi = Adh_i/dt + Bh_i$

$x = (hr- hi)\ (a/b)$

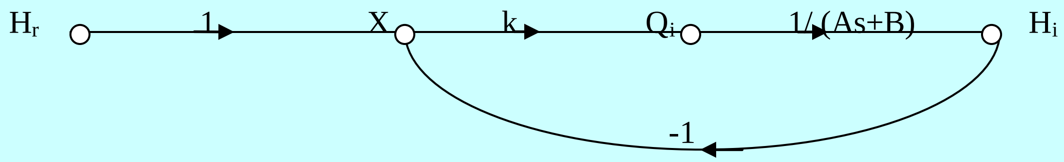
$q_i = kx$

Taking the Laplace transforms, we have after rearranging

$X = (H_r - H_i)\ (a/b)$

$Q_i = kX$

$H_i = Qi/\ (As+B)$



(b)

$C/R = G_1G_2G_3/\ (1+ G_1G_2G_3+G_3H_1)$

TOP

Problem 12 To determine the magnitude and phase angle of G ($j\omega$)

(a) Describe a subroutine and draw a flow-chart for obtaining the magnitude and angle of G ($j\omega$) when the transfer function is

$$G(s) = \frac{10}{s(1+0.25s)[(s^2+10s+64)/64]}.$$

(b) Determine the magnitude and angle of G ($j\omega$) for the transfer function G(s) of Part (a).

Solution

(b) $$G(jw) = \frac{10}{jw(1+.25jw)(64-w^2+j10w)/64}$$

Let G (jw) = 10G1(jw) G2 (jw) G3(jw)

Mag.G1 (jw) = 1/w

Mag.G2 (jw) = 1/sqrt $(1+(.25w)^2)$

Mag.G3 (jw) = 64/sqrt $((64-w^2)+(10w)^2)$

Angle G1 (w) = -45deg = -1.57 rad.

Angle G2 (w) = - $\tan^{-1}$.25w rad.

Angle G3 (w) =- $\tan^{-1}\dfrac{10w}{(64-w^2)}$

TOP

Problem 13 Solution of a second-order differential equation

(a) Find the 2 x 2 matrices X and Y such that AX =B and YA =B , where

$$A = \begin{pmatrix} 2 & -1 \\ -3 & 2 \end{pmatrix} \qquad B = \begin{pmatrix} 3 & 2 \\ -6 & -5 \end{pmatrix}$$

(b) Find the eigenvalues of the matrix:

$$A = \begin{pmatrix} 2 & 1 & 1 \\ 2 & 3 & 4 \\ -1 & -1 & -2 \end{pmatrix}$$

(c) Using the state variables: $x_1 = y$, $x_2 = dy/dt$, determine the solution of the following differential equation:

$d^2y/dt^2 + 5\, dy/dt + 6y = 0$.

The initial conditions are $y(0) = 1$, $dy/dt\,(0) = 0$.

Solution

(a) $A^{-1} = \begin{pmatrix} 2 & 1 \\ 3 & 2 \end{pmatrix}$ $\qquad X = A^{-1}B = \begin{pmatrix} 0 & -1 \\ -3 & -4 \end{pmatrix}$

$Y = B\,A^{-1} = \begin{pmatrix} 12 & 7 \\ -27 & -16 \end{pmatrix}$

(b)

Eigenvalues are given by the characteristic equation

$$\begin{pmatrix} 2-\lambda & 1 & 1 \\ 2 & 3-\lambda & 4 \\ -1 & -1 & -2-\lambda \end{pmatrix} = 0$$

Thus, $\lambda = 1, -1, 3$

(c) The state space representation is

dx1/dt = x2
dx2/dt = -6x1- 5x2

Laplace transform is

SX1(s) –x1 (0) =X2(s)
SX2(s) –x2 (0) =-6X1(s) –5X2(s)

$$\text{Matrix } A = \begin{pmatrix} 0 & 1 \\ -6 & -5 \end{pmatrix}$$

$$\phi(s) = (sI-A)^{-1} = \begin{pmatrix} \frac{3}{(s+2)} - \frac{2}{(s+3)} & \frac{1}{(s+2)} - \frac{1}{(s+3)} \\ \frac{-6}{(s+2)} + \frac{6}{(s+3)} & \frac{-2}{(s+2)} + \frac{3}{(s+3)} \end{pmatrix}$$

Find $\phi(t)$. Solution is: x (t) = $\phi(t)$. x (0).

Therefore, y = 3exp(-2t) 2exp(-3t)

dy/dt = -6(exp (-2t) –exp (-3t)

TOP

Problem 14 To determine the roots of a polynomial

(a) Describe a subroutine and draw a flow-chart to determine the polynomial whose roots are located at s = -a, s = -b, and s = -c respectively.

(b) Determine the roots of the following polynomial:

$$4s^3 - 20s^2 + 17s + 14 = 0$$

(c) Find the inverse Laplace transform of the following function:

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

Solution

(b) $4s3-20s^2+17s+14 = 0$

The exact roots are –0.5,2, 3.5

(c) Partial fraction expansion is $F(s) = 2/(s+1)^3 + 1/(s+1)$

$f(t) = (t^2+1) \exp(-t), t \geq 0$

TOP

Problem 15 : Transfer function using Mason's Rule

(a) The block diagram of a control system is shown in Fig.10.
Using block-diagram reduction, find the transfer function, C(s)/R(s).

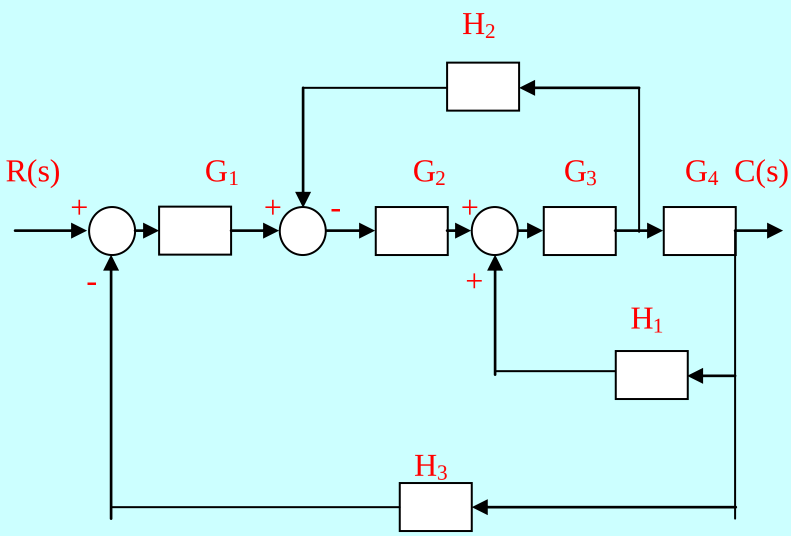


Fig.10

(b) Find the transfer function, C(s)/R(s) using Mason's Rule also.

Solution

(a) Transfer function after block diagram reduction

$C(s)/R(s) = G_1G_2G_3G_4/ (1- G_3G_4H_1+ G_2G_3H_2+ G_1G_2G_3G_4H_3)$

(b)Transfer function= $P_1\ \Delta_1/ (1-L_1-L_2-L_3)$

$P1= G_1G_2G_3G_4$

$L_1 = - G_2G_3H_2$

$L_2 = - G_3G_4H_1$

$L_3 = - G_1G_2G_3G_4H_3$

Path P_1 touches all the loops. Hence Δ_1=1.

Transfer function is given in Part (a)
TOP

Problem 16 Roots of a third-order polynomial

(a) Describe a method of determining the roots of a third –order polynomial.
(b) Determine the roots of a polynomial
$s^3+4s^2+6s+4=0$
(c) Obtain the partial fraction expansion of

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

Solution

(b):
$F(s) = s^3 +4s^2 +6s +4$

Table of synthetic division is :

1 4 6 4 $\angle$-1 = trial root

1   -3 -3

1   3   3 | 1 = remainder

for a trial root of s= -1. In this Table, multiply the trial root and successively add in each column. With a remainder of 1 ,try

s = -2 which results in

1   4   6   4∠-2   = trial root

-2 -2 -4

1   2   2 | 0= remainder

Because the remainder is zero, one root is s=-2.

Let(s+2) (s^2 +as + b) = 0. Comparing coefficients, a = 2, b =2. Therefore, the remaining roots are: s=-1+j and –1-j.

(c) F(s) =(1/s) +(2/(s+1))   -(1/(s+2))

TOP

Problem 16

OBJECTIVE TYPE QUESTIONS:

Choose the correct answers from those given below:
by writing (a), (b), or (c):

(i) The partial fraction expansion of $2\frac{(x^2+3x+1)}{x(x+1)(x+2)}$ is

$$\frac{A_1}{x} + \frac{A_2}{(x+1)} + \frac{A_3}{(x+2)}$$

where

(a) $A_1 = 1$, $A_2 = -2$, $A_3 = -1$
(b) $A_1 = 1$, $A_2 = 2$, $A_3 = 1$
(c) $A_1 = 1$, $A_2 = -1$, $A_3 = -2$

Ans: (a)

(ii) The eigenvalues of the matrix $\begin{pmatrix} 0 & 1 \\ & \end{pmatrix}$

-6 -5

are:

(a) –1 and –2
(b) –2 and –3
(c) –3 and –4

Ans: (b)

(iii) Which one of the following properties of the root locus is *not* true?

(a) A branch of the root locus starts from each open-loop pole and terminates at each open-loop zero at infinity

(b) The root locus is symmetrical about the real axis of the *s*-plane.

(c) If the number of finite zeros *m* is less than the number of finite poles *n*, then *n*+*m* branches of the root locus must end at zeros at infinity.

Ans: (c)

(iv) The transfer function of a system is

$$\frac{10(1+0.2s)}{(1+0.5s)}$$

The corner frequencies will be

(a) 0^0 and-90^0
(b) 180^0 and-180^0
(c) 90^0 and-90^0

Ans: (a)

(v) Which one of the following statements is not true?

(a) The eigenvalues of the matrix $B = P^{-1}AP$ cannot be the same as those of A, when P is any nonsingular matrix.
(b) A matrix of order n will have n eigenvalues, which may not all be distinct (i.e. some eigenvalues may be repeated).
(c) The sum of the eigenvalues of a matrix is equal to the negative of its trace. (The trace of a matrix is equal to the sum of the elements on its main diagonal).

Ans: (a)

(vi)Which one of the following statements is true?

(a) The multiplication of a row vector and a column vector is a column vector
(b) The multiplication of a row vector and a column vector is a square matrix
(c) The multiplication of a row vector and a column vector is a scalar quantity

Ans: (c)

(vii) The roots of the cubic equation

$x^3 + 3x^2 + 4x + 2 = 0$

are
(a) 2, 3 and 4
(b) -1, -1 +j, -1 –j
(c) 1, 1+j, 1-j

Ans: (b)

(viii) The Laplace inverse transform of

$F(s) = 10(s^2+2s+5)/ [(s+1)(s^2+6s+25)]$

is
(a) $e^{-t} + e^{-3t}(8\cos 4t - 6\sin 4t)$
(b) $2e^{-t} + e^{-3t}(3\cos 4t - 4\sin 4t)$
(c) $2e^{-t} + e^{-3t}(8\cos 4t - 6\sin 4t)$

Ans: (c)

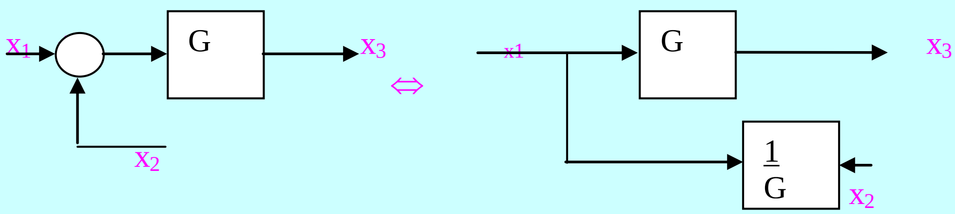
(ix) Which one of the following statements is not true?

(a) The transfer function of a system (or element) does not represent the relationship describing the dynamics of the system
(b) A transfer function may only be defined for a linear, stationary (constant parameter) system
(c) The Laplace transformation may not be utilized for a time-varying system.
(d) The transfer function description does not include any information concerning the internal structure of the system and its behaviour.

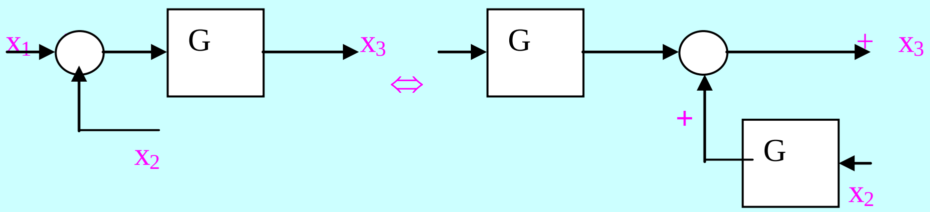
Ans: (a)

(x) Which one of the of the following set of block diagrams is equivalent?

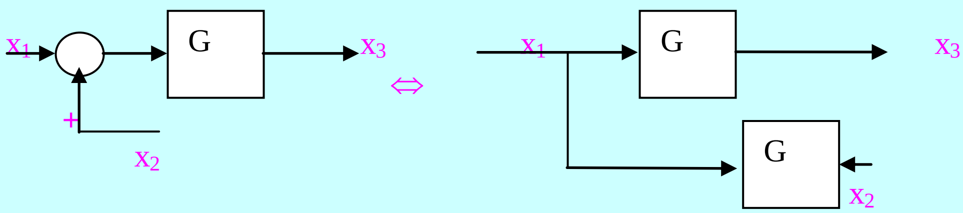
(a)



(b)



(c)



The symbol ⇔ stands for equivalence.

Ans: (b)

(x) A servo-mechanism is called a proportional error device when the output of the system is
(a) a function of error and the first derivative of error

(b) a function of the first derivative of error only
(c) a function of error only
(d) none of the above.

Ans :(c)

(xi) Fig.11 shows a differentiating circuit.

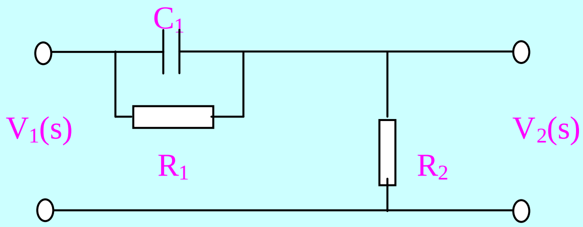


Fig.11

The transfer function of the circuit, $V2(s)/V_1(s)$, is

(a) $R_2/(1 + s\,CR_1)$

(b) $\dfrac{(s + 1/R_1C)}{s+ (R_1+R_2)/R_1R_2C}$

(c) $R_1/(1 + s\,CR_2)$

(d) $\dfrac{(s + 1/R_2C)}{s+ (R_1+R_2)/R_1R_2C}$

Ans :(b)

(xii) A home heating feedback- control system consists of the valve which controls the gas or power input, the heater, and the thermo-sensor. Which one of the following statements is true?

(a) The heater is in the feedback path
(b) The valve is in the feedback path
(c) The thermo-sensor is in the feedback path
(d) The thermo-sensor is in the forward path

Ans :(c)

(xiii) Match List E that gives the physical element with List F that gives the type of element.

List E-	List F
A-Translational spring	I-Energy dissipater
B-Rotational mass	II-Capacitive storage
C-Thermal resistance	III-Inductive storage

-

The correct matching is

(a) AIII BII CI
(b) AII BI CIII
(c)AI BIII CII

Ans: (a)

(xiv) In general, the programmer does not write the computer program in machine language, because

(a) The program is not executable by the machine.

(b)It is a tedious job for the programmer and is best left to the machine to convert the source program to the machine language program.
(c) There is no need to do it
(d) The machine takes more time to solve the required problem.

Ans: (b)

(xv) Which of the following statements is true?

(a) The FORTRAN compiler changes the object program to the source program.
(b) FORTRAN language is the same as the machine language
(c) It is the object program that is actually executed by the computer to obtain results
(d) The computer executes the source program to obtain the results.

Ans: (c)

(xvi) Programming is a difficult task in one of the following
:

(a) Analogue computer
(b) Digital computer
(c) Microprocessor or microcomputer
(d) Minicomputer.

Ans: (c)

(xvi) The number of roots of the polynomial

$s^4+2s^3+4s^2+8s+15 = 0$

in the right-half of the s-plane are:

(ii.) Four
(ii)None (two pairs of roots on the jω axis)
(iii.) None (two roots on the jω axis)
(iv.) Two.

Ans: (d)

(xvii) Choose the correct answers from those given below:

i. The following matrix is singular

$$\begin{bmatrix} 1 & 1 & 2 \\ 2 & 0 & 2 \\ 3 & 1 & 2 \end{bmatrix}$$

FALSE

ii. The Laplace transform of

$$f(t) = \frac{1}{(b-a)} \cdot (be^{-bt} - ae^{-at})$$

is

F(s) = 1

$$\frac{\qquad}{(s+a)(s+b)} \; .$$

TRUE

(xviii) The partial fraction expansion of

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

is

(a) $\dfrac{2}{(s+1)^3} + \dfrac{1}{(s+1)}$

(b) $\dfrac{2}{(s+1)^3} + \dfrac{3}{(s+1)}$

(c) $\dfrac{1}{(s+1)^3} + \dfrac{2}{(s+1)^2} + \dfrac{3}{(s+1)}$

(d) $\dfrac{1}{(s+1)^3} + \dfrac{3}{(s+1)}$

Ans: a

(xix) The transfer function, $E_o(s)/E_i(s)$ of the ideal resonant filter of Fig.12 is

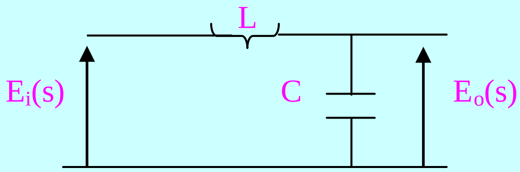


Fig.12

(a) $\underline{s^2LC}$

s^2LC+1

(b) Zero

(c) Unity

(d)1/ (s^2LC+1)

Ans: (d)

(xx) Modern control theory

(a) is not applicable to multiple-input-multiple-output systems, non-linear systems and time-varying systems
(b) is essentially a time-domain approach, while conventional control theory is a frequency domain approach
(c)does not enable us to design optimal control systems with specific performance indices.
(c) does not enable us to include initial conditions in the design of the control system.

Ans: (b)

(xxi) The resultant equivalent transfer function C(s)/R(s) of the system shown in Fig.13 is

(a) G1G2/(1+G1G2H1)
(b) G1G2/(1+G1G2+G1G2H1)
(c) G1G2/(1+G1G2+G2H1)
(d) G1G2/(1+G1G2+G1H1)

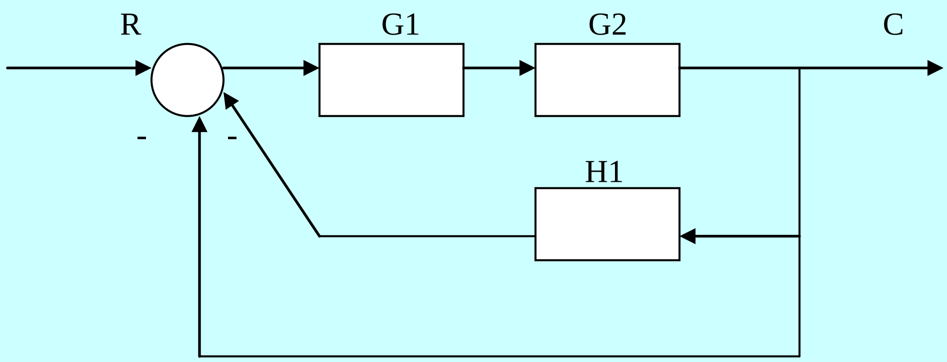


Fig.13

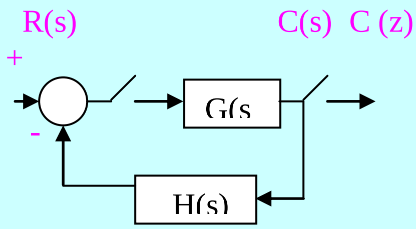
Ans: (b)

(xxii) Match List E with List F in the following Table of closed-loop systems and their outputs, C (z).

List E

List F

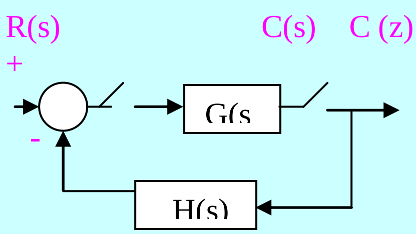
A



I

$$C(z) = \frac{RG(z)}{1+HG(z)}$$

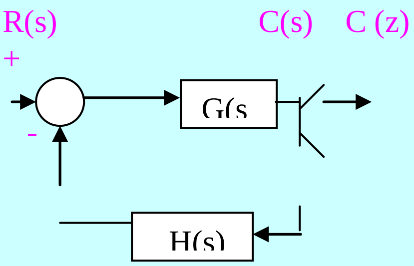
B



II

$$C(z) = \frac{G(z)\,R(z)}{1+G(z)\,H(z)}$$

C



III

$$C(z) = \frac{G(z)\,R(z)}{1+GH(z)}$$

The correct matching is
(a)AIII BII CI
(b)AI BIII CII
(c)AII BIII CI
(d)AI BIICIII

Ans: (a)

TOP