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ESE 2021

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Preliminary Examination

Electrical Engineering

Topicwise **Objective** Solved Questions

Volume-II

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Director's Message

Engineering is one of the most chosen graduating field. Taking engineering is usually a matter of interest but this eventually develops into "purpose of being an engineer" when you choose engineering services as a carrier option.

B. Singh (Ex. IES)

Train goes in tunnel we don't panic but sit still and trust the engineer, even we don't doubt on signalling system, we don't think twice crossing over a bridge reducing our travel time; every engineer has a purpose in his department which when coupled with his unique talent provides service to mankind.

I believe *"the educator must realize in the potential power of his pupil and he must employ all his art, in seeking to bring his pupil to experience this power"*. To support dreams of every engineer and to make efficient use of capabilities of aspirant, MADE EASY team has put sincere efforts in compiling all the previous years' ESE-Pre questions with accurate and detailed explanation. The objective of this book is to facilitate every aspirant in ESE preparation and so, questions are segregated chapterwise and topicwise to enable the student to do topicwise preparation and strengthen the concept as and when they are read.

I would like to acknowledge efforts of entire MADE EASY team who worked hard to solve previous years' papers with accuracy and I hope this book will stand up to the expectations of aspirants and my desire to serve student fraternity by providing best study material and quality guidance will get accomplished.

B. Singh (Ex. IES)
CMD, MADE EASY Group

Contents

Electrical Engineering

Volume-II

Objective Solved Questions

of UPSC Engineering Services Examination

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UNIT II

Control Systems

Syllabus

Principles of feedback, transfer function, block diagrams and signal flow graphs, steady-state errors, transforms and their applications; Routh-hurwitz criterion, Nyquist techniques, Bode plots, root loci, lag, lead and lead-lag compensation, stability analysis, transient and frequency response analysis, state space model, state transition matrix, controllability and observability, linear state variable feedback, PID and industrial controllers.

Contents

1 Modelling of a Control System & Transfer Function Approach

1.1 Match **List-I** (Physical action or activity) with **List-II** (Category of system) and select the correct answer:

List-I

A. Human respiration system
B. Pointing of an object with a finger
C. A man driving a car
D. A thermostatically controlled room heater

List II

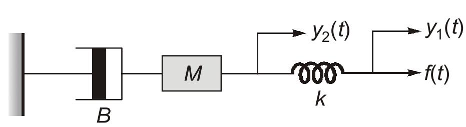
1. Man-made control system
2. Natural including biological control system
3. Control system whose components are both man-made and natural

Codes:

	A	B	C	D
(a)	2	2	3	1
(b)	3	1	2	1
(c)	3	2	2	3
(d)	2	1	3	3

[ESE-2001]

1.2 The mechanical system is shown in the given figure



The system is described as:

(a) $M\dfrac{d^2y_1(t)}{dt^2}+B\dfrac{dy_1(t)}{dt}=k[y_2(t)-y_1(t)]+f(t)$

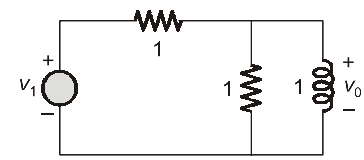
(b) $M\dfrac{d^2y_2(t)}{dt^2}+B\dfrac{dy_2(t)}{dt}=k[y_2(t)-y_1(t)]+f(t)$

(c) $M\dfrac{d^2y_1(t)}{dt^2}+B\dfrac{dy_1(t)}{dt}=k[y_1(t)-y_2(t)]+f(t)$

(d) $M\dfrac{d^2y_2(t)}{dt^2}+B\dfrac{dy_2(t)}{dt}=k[y_1(t)-y_2(t)]+f(t)$

[ESE-2001]

1.3 Select the correct transfer function $v_0(s)/v_1(s)$ from the following for the given network.

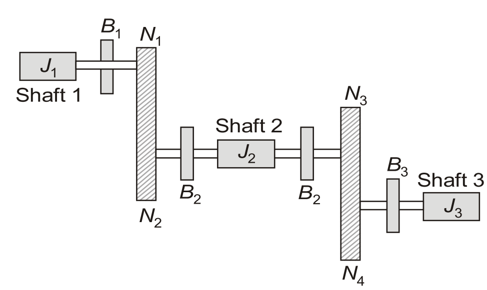


(a) $\dfrac{2}{s(s+1)}$ (b) $\dfrac{s}{(s+2)}$

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

[ESE-2002]

1.4 Consider the following diagram:



For the multiple gear system shown above, which one of the following gives the equivalent inertia referred to shaft 1?

(a) $J_1+J_2\left(\dfrac{N_1}{N_2}\right)^2+J_3\left(\dfrac{N_1N_3}{N_2N_4}\right)^2$

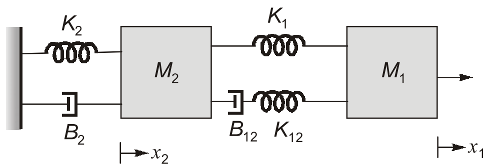
(b) $J_1+J_2\left(\dfrac{N_2}{N_1}\right)^2+J_3\left(\dfrac{N_2N_4}{N_1N_3}\right)^2$

(c) $J_1+J_2\left(\dfrac{N_1}{N_2}\right)^2+J_3\left(\dfrac{N_1N_2}{N_3N_4}\right)^2$

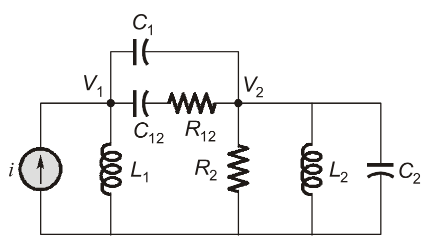
(d) $J_1+J_2\left(\dfrac{N_2}{N_1}\right)^2+J_3\left(\dfrac{N_1N_2}{N_3N_4}\right)^2$

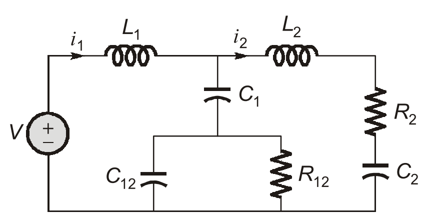
[ESE-2004]

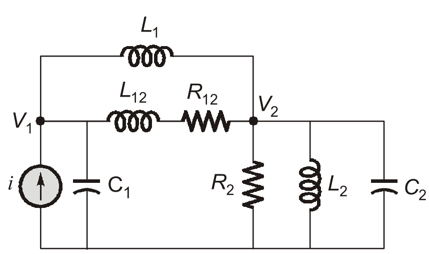
1.5 Consider the following mechanical system shown in the diagram:

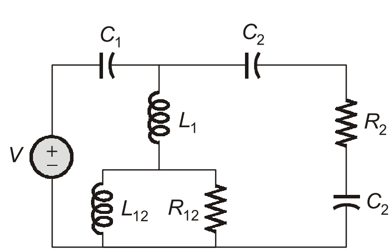


Which one of the following circuits shows the correct force-current analogous electrical circuit for the mechanical diagram shown above?

(a)


(b)


(c)


(d)


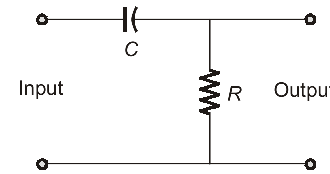
[ESE-2004]

1.6 The maximum temperature rise of a trans-former is 50°C. It attains a temperature 31.6° in 1/2 hour. What its thermal time constant?

(a) 2 hours (b) 1/2 hours
(c) 1 hours (d) 1/4 hours

[ESE-2005]

1.7 The transfer function for the diagram shown below is given by which one of the following?



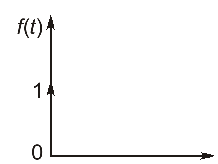
(a) $\dfrac{1}{(1+sRC)}$ (b) $\dfrac{sRC}{(1+sRC)}$

(c) $\dfrac{sRC}{(1-sRC)}$ (d) $1 + sRC$

[ESE-2008]

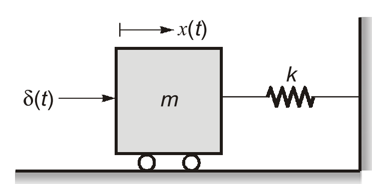
1.8 What does the function $f(t)$ plotted in the below figure represent?

(a) Unit step function
(b) Unit impulse function
(c) Unit ramp function
(d) Unit parabolic function



[ESE-2008]

1.9 A mechanical system is as shown in the figure below. The system is set into motion by applying a unit impulse force $\delta(t)$. Assuming that the system is initially at rest and ignoring friction, what is the displacement $x(t)$ of mass?

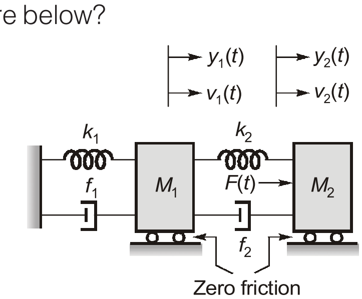


(a) $\dfrac{1}{\sqrt{k}}\exp(-m\cdot t)$ (b) $\dfrac{1}{\sqrt{mk}}\sin(t)$

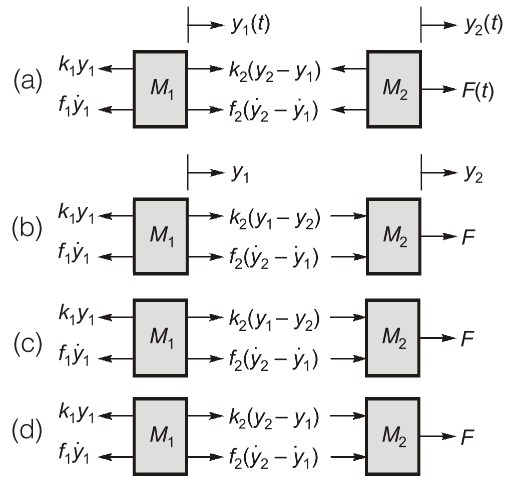
(c) $\dfrac{1}{\sqrt{mk}}\sin\left(\sqrt{\dfrac{k}{m}}\cdot t\right)$ (d) $\dfrac{1}{\sqrt{mk}}\left(\sqrt{\dfrac{k}{m}}\cdot t\right)$

[ESE-2009]

1.10 Which one of the following is the correct free body diagram for the physical system as shown in the figure below?

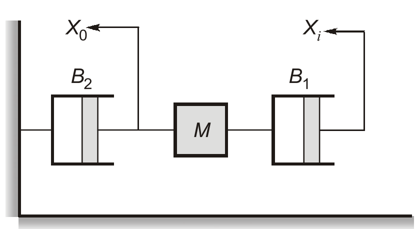


$y_1(t)$ and $y_2(t)$ are displacements
$v_1(t)$ and $v_2(t)$ are velocities.



[ESE-2009]

1.11 For the mechanical system with mass and viscous friction components, shown in figure, $\frac{X_0(s)}{X_i(s)}$ is



(a) $\frac{B_2}{Ms + B_1 + B_2}$ (b) $\frac{1}{Ms + (B_1 + B_2)}$

(c) $\frac{B_1}{Ms + B_1 + B_2}$ (d) None of these

[ESE-2011]

1.12 Match **List-I** with **List-II** and select the correct answer using the code given below the lists:

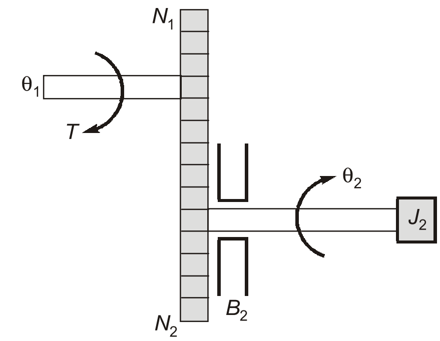
List-I	List-II
A. Mass	**1.** Capacitor
B. Damper	**2.** Voltage
C. Spring	**3.** Resistor
D. Force	**4.** Inductor

Codes:

	A	B	C	D
(a)	2	1	3	4
(b)	4	1	3	2
(c)	2	3	1	4
(d)	4	3	1	2

[ESE-2011]

1.13 Consider the following relations with regard to the below shown gear trains:



1. $\frac{\theta_1}{\theta_2} = \frac{N_2}{N_1}$

2. $T_2 = J_2 \frac{d^2\theta_2}{dt^2} + B_2 \frac{d\theta_2}{dt}$

3. $T_1 = J_2 \left(\frac{N_1}{N_2}\right)^2 \frac{d^2\theta_1}{dt^2} + B_2 \left(\frac{N_1}{N_2}\right)^2 \frac{d\theta_1}{dt}$

Which of these relations are correct?

(a) 1, 2 and 3 (b) 1 and 2 only
(c) 2 and 3 only (d) 1 and 3 only

[ESE-2011]

1.14 The law/principle in mechanical systems, analogous to Kirchhoff's laws in electrical systems, is

(a) first law of motion
(b) second law of motion
(c) third law of motion
(d) d'Alembert's principle

[ESE-2012]

1.15 Match **List-I** (Mechanical translation system) with **List-II** (Electrical element for analogous) and select the correct answer using the code given below the lists:

List-I	List-II
A. Mass	**1.** Resistor
B. Damper	**2.** Inductor
C. Spring	**3.** Capacitor
D. Displacement	**4.** Charge

Codes:

	A	B	C	D
(a)	4	3	1	2
(c)	2	3	1	4
(c)	4	1	3	2
(d)	2	1	3	4

[ESE-2012]

1.16 When deriving the transfer function of a linear element
(a) both initial conditions and loading are taken into account
(b) initial conditions are taken into account but the element is assumed to be not loaded.
(c) initial conditions are assumed to be zero but loading is taken into account
(d) initial conditions are assumed to be zero and the element is assumed to be not loaded.
[ESE-2013]

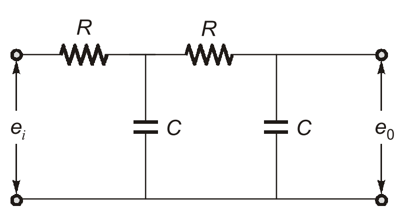
1.17 An open loop T.F. of a unity feedback system is given by

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

The closed loop transfer function will have poles at
(a) –2, –2 (b) –2, –1
(c) $-2 + j, -2 - j$ (d) –2, 2
[ESE-2013]

1.18 A transfer function has its zero in the right half of the s-plane. The function
(a) is positive real
(b) is minimum phase
(c) will give stable impulse response
(d) is non-minimum phase
[ESE-2013]

1.19 The transfer function of the network shown below is



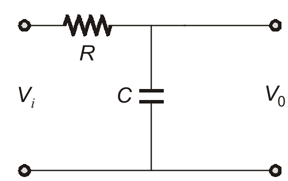
(a) $\frac{1}{s^2T^2+2sT+1}$ (b) $\frac{1}{s^2T^2+3sT+1}$
(c) $\frac{1}{s^2T^2+sT+1}$ (d) $\frac{1}{s^2T^2+1}$
[ESE-2013]

1.20 **Statement (I):** Servo motors have small diameter and large axial length.
Statement (II): Servo motors must have low inertia and high starting torque.

Codes:
(a) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I).
(b) Both Statement (I) and Statement (II) are individually true but Statement (II) is not the correct explanation of Statement (I).
(c) Statement (I) is true but Statement (II) is false.
(d) Statement (I) is false but Statement (II) is true.
[ESE-2014]

1.21 The transfer function of a low-pass *RC* network is
(a) $RCs(1 + RCs)$ (b) $\frac{1}{(1+RCs)}$
(c) $\frac{RC}{(1+RCs)}$ (d) $\frac{s}{(1+RCs)}$
[ESE-2014]

1.22 The transfer function of the circuit as shown in the figure is expressed as



(a) $\frac{R}{1+sRC}$ (b) $\frac{s}{1+sCR}$
(c) $\frac{1}{1+sRC}$ (d) $1 + sCR$
[ESE-2015]

1.23 The servomotor differs from the standard motors principally in that, it has
(a) entirely different construction
(b) high inertia and hence high torque
(c) low inertia and low torque
(d) low inertia and higher starting torque
[ESE-2015]

1.24 The desirable features of a servomotor are
(a) low rotor inertia and low bearing friction
(b) high rotor inertia and high bearing friction
(c) low rotor inertia and high bearing friction
(d) high rotor inertia and low bearing friction
[ESE-2016]

■■■■

Answers Modelling of a Control System and Transfer Function Approach

1.1 (a)	1.2 (d)	1.3 (c)	1.4 (a)	1.5 (c)	1.6 (b)	1.7 (b)	1.8 (b)	1.9 (c)
1.10 (a)	1.11 (c)	1.12 (d)	1.13 (a)	1.14 (d)	1.15 (d)	1.16 (d)	1.17 (c)	1.18 (d)
1.19 (b)	1.20 (a)	1.21 (b)	1.22 (c)	1.23 (d)	1.24 (a)			

Explanations Modelling of a Control System and Transfer Function Approach

1.3 (c)

Applying nodal analysis

$$V_1 - V_0 = V_0 + \frac{V_0}{s}$$

$$V_1 = 2V_0 + \frac{V_0}{s}$$

$$V_1 = V_0\left(\frac{2s+1}{s}\right)$$

$$\therefore \quad \boxed{\frac{V_0}{V_1} = \frac{s}{2s+1}}$$

1.6 (b)

$$31.6 = (1 - e^{-t/\tau})$$

$$\Rightarrow \quad \tau = \frac{1}{2} \text{ hour}$$

1.7 (b)

$$\text{T.F.} = \frac{V_0}{V_i} = \frac{R}{R+\frac{1}{Cs}} = \frac{RCs}{1+RCs}$$

1.9 (c)

$$\delta(t) = \frac{md^2x(t)}{dt^2} + k\,x(t)$$

Taking laplace transform

$$1 = ms^2 X(s) + k\,[X(s)]$$

$$\therefore \quad X(s) = \frac{1}{ms^2+k}$$

$$X(s) = \frac{1}{m\left[s^2+\frac{k}{m}\right]}$$

$$X(t) = \frac{1}{\sqrt{mk}} \sin\left(\sqrt{\frac{k}{m}}\cdot t\right)$$

1.11 (c)

Dynamic equation,

$$M\frac{d^2x_0}{dt^2} + B_2\frac{dx_0}{dt} + B_1\frac{d}{dt}(x_0 - x_i) = 0$$

$$MX_0(s)s^2 + B_2X_0(s)s + B_1(X_0(s) - X_i(s))s = 0$$

$$\frac{X_0(s)}{X_i(s)} = \frac{B_1 s}{Ms^2 + (B_1+B_2)s}$$

$$= \frac{B_1}{Ms + B_1 + B_2}$$

1.12 (d)

	Voltage analogy	Current analogy
Force	Voltage	Current
Mass	Inductor	Capacitor
Spring	$1/C$	$1/L$
Damper	R	$1/R$

Hence, option (d) is correct.

1.13 (a)

Number of teeth is proportional to the radius

$$\frac{r_1}{r_2} = \frac{N_1}{N_2}.$$

Distance travelled on the surface of the gear is the same for both $r_1\theta_1 = r_2\theta_2 \Rightarrow \frac{r_1}{r_2} = \frac{\theta_2}{\theta_1}$.

Work done by one gear is equal to the other

$$T_1\theta_1 = T_2\theta_2 \Rightarrow \frac{T_1}{T_2} = \frac{\theta_2}{\theta_1}$$

$$\text{Combining,} \quad \frac{T_1}{T_2} = \frac{\theta_2}{\theta_1} = \frac{N_1}{N_2} = \frac{r_1}{r_2} = \frac{\omega_2}{\omega_1}$$

Torque on one gear can be transferred to other gear similar to transformer's transferred impedance with ratio N_1/N_2.

Hence, option (a) is correct.

1.14 (d)

D'Alembert's principle for the translational mechanical system is as follows:

The algebraic sum of the externally applied forces on a given body and the force resisting the motion of the body in a given direction is zero.

1.15 (d)

By comparing displacement with charge, we came to know that it is force voltage analogy, mass is analogous to inductor, damper to resistor, spring to capacitor and displacement to charge.

1.16 (d)

While deriving the transfer function of a linear element only initial conditions are assumed to be zero, whereas it is independent of loading condition.

1.17 (c)

$$\text{OLTF} = G(s) = \frac{1}{(s+2)^2}$$

For unity feedback system, $H(s) = 1$

$$\therefore \quad \text{CLTF} = \frac{G(s)}{1+G(s)H(s)} = \frac{\frac{1}{(s+2)^2}}{1+\frac{1}{(s+2)^2}}$$

$$= \frac{1}{s^2+4s+5}$$

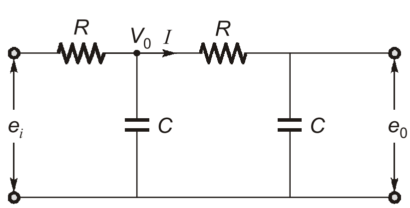
∴ Closed loop poles will be the roots of $s^2 + 4s + 5 = 0$

i.e. $s = -2 + j$ and $-2 - j$

1.18 (d)

Non-minimum phase functions have their zeros in the right half of the s-plane.

1.19 (b)



$$E_o(s) = \frac{1}{sC} I(s) \qquad \ldots(i)$$

$$I(s) = \frac{E_i(s)}{\frac{\left(R+\frac{1}{sC}\right)\times\frac{1}{sC}}{R+\frac{1}{sC}\times\frac{1}{sC}+R}} \times \frac{\frac{1}{sC}}{R+\frac{1}{sC}+\frac{1}{sC}}$$

(Using current division rule)

$$= \frac{E_i(s)}{\frac{R+\frac{1}{sC}}{sCR+2}+R} \times \frac{1}{sCR+2}$$

$$I(s) = \frac{E_i(s)}{R+\frac{1}{sC}+sCR^2+2R} \times \frac{sCR+2}{sCR+2}$$

Using equation (i),

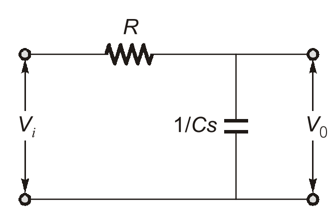
$$\frac{E_o(s)}{\frac{1}{sC}} = \frac{E_i(s)}{sCR^2+\frac{1}{sC}+3R}$$

$$\therefore \quad \text{T.F.} = \frac{E_o(s)}{E_i(s)} = \frac{\frac{1}{sC}}{sCR^2+3R+\frac{1}{sC}}$$

$$= \frac{1}{s^2C^2R^2+3sCR+1}$$

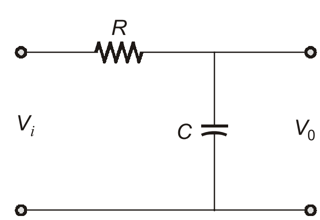
$$= \frac{1}{s^2T^2+3sT+1} \qquad (\because T = RC)$$

1.21 (b)



$$\frac{V_0}{V_i} = \frac{1/Cs}{R+\frac{1}{Cs}} = \frac{1}{RCs+1}$$

1.22 (c)

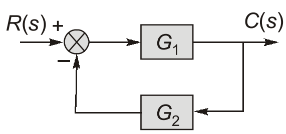


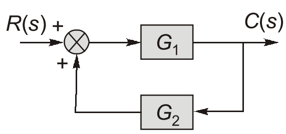
$$\frac{V_0(s)}{V_i(s)} = \frac{\frac{1}{sC}}{R+\frac{1}{sC}} = \frac{1}{1+sRC}$$

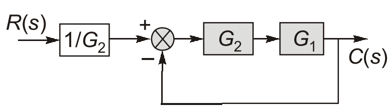
■■■■

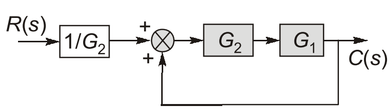
2 Block Diagram, Signal Flow Graph and Feedback Characteristics of Control Systems

2.1 Consider the following block diagrams :

1. 

2. 

3. 

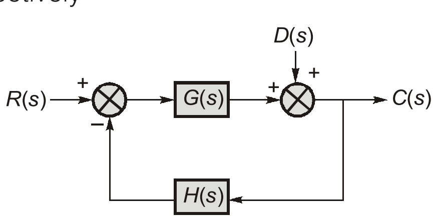
4. 

Which of these block diagrams can be reduced to transfer function $\frac{C(s)}{R(s)} = \frac{G_1}{1 - G_1 G_2}$?

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

[ESE-2001]

2.2 In the feedback system $C(s)$, $R(s)$ and $D(s)$ are the system output, input and disturbance, respectively



Assertion (A): For system

$$\frac{C(s)\{R(s)+D(s)\}}{R(s)D(s)} = \frac{1+G(s)}{1+G(s)H(s)}$$

Reason (R): Transfer function of a system is defined as the ratio of output Laplace transform and input Laplace transform setting other inputs and the initial conditions to zero.

(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE-2001]

2.3 Which of the following are the characteristics of closed loop systems?

1. It does not compensate for disturbances.
2. It reduces the sensitivity of plant-parameter variations.
3. It does not involve output measurements.
4. It has the ability to control the system transient response.

Select the correct answer using the codes given below:

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

[ESE-2002]

2.4 Match **List-I** (Property) with **List-II** (Specification) and select the correct answer:

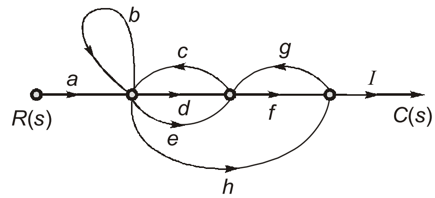
List-I	List-II
A. Relative stability	**1.** Rise time
B. Speed of response	**2.** Velocity error constant
C. Accuracy	**3.** Return difference
D. Sensitivity	**4.** M-peak

Codes:

	A	B	C	D
(a)	4	3	2	1
(b)	2	1	4	3
(c)	4	1	2	3
(d)	2	3	4	1

[ESE-2002]

2.5 The number of forward paths and the number of non-touching loop pairs for the signal flow graph given in the figure below are, respectively.

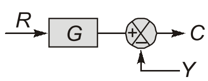


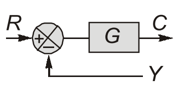
(a) 1, 3 (b) 3, 2
(c) 3, 1 (d) 2, 4

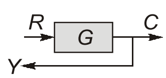
[ESE-2002]

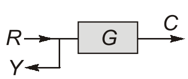
2.6 Match **List-I** (Block Diagram) with **List-II** (Transformed Block Diagram) and select the correct answer:

List-I

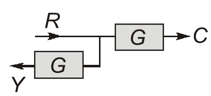
A. 

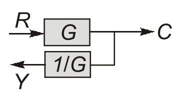
B. 

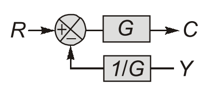
C. 

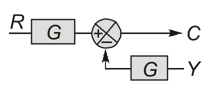
D. 

List-II

1. 

2. 

3. 

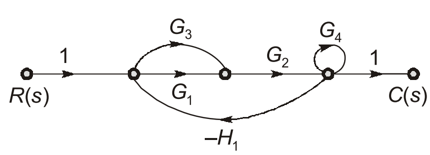
4. 

Codes:

	A	B	C	D
(a)	3	4	2	1
(b)	4	3	1	2
(c)	3	4	1	2
(d)	4	3	2	1

[ESE-2003]

2.7 The gain $C(s)/R(s)$ of the signal flow graph shown below is



(a) $\dfrac{G_1G_2 + G_2G_3}{1 + G_1G_2H_1 + G_2G_3H_1 + G_4}$

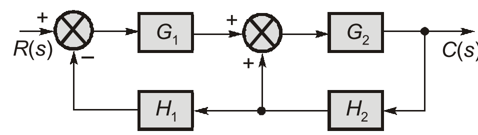
(b) $\dfrac{G_1G_2 + G_2G_3}{1 + G_1G_2H_1 + G_2G_3H_1 - G_4}$

(c) $\dfrac{G_1G_3 + G_2G_3}{1 + G_1G_3H_1 + G_2G_3H_1 + G_4}$

(d) $\dfrac{G_1G_3 + G_2G_3}{1 + G_1G_3H_1 + G_2G_3H_1 + G_4}$

[ESE-2003]

2.8 The overall gain $\dfrac{C(s)}{R(s)}$ of the block diagram shown below is



(a) $\dfrac{G_1G_2}{1 - G_1G_2H_1H_2}$

(b) $\dfrac{G_1G_2}{1 - G_2H_2 - G_1G_2H_1}$

(c) $\dfrac{G_1G_2}{1 - G_2H_2 + G_1G_2H_1H_2}$

(d) $\dfrac{G_1G_2}{1 - G_1G_2H_1 - G_1G_2H_2}$

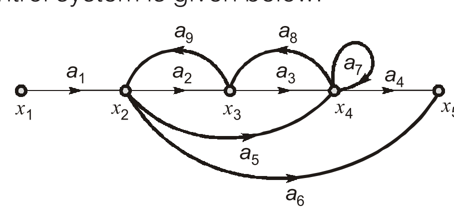
[ESE-2003]

2.9 Which one of the following effects in the system is NOT caused by negative feedback?

(a) Reduction in gain
(b) Increase in bandwidth
(c) Increase in distortion
(d) Reduction in output impedance

[ESE-2003]

2.10 The signal flow graph for a certain feedback control system is given below:



Now consider the following set of equations for the nodes:

1. $x_2 = a_1x_1 + a_9x_3$
2. $x_3 = a_2x_2 + a_8x_4$
3. $x_4 = a_3x_3 + a_5x_2$
4. $x_5 = a_4x_4 + a_6x_2$

Which of the above equations are correct?

(a) 1, 2 and 3 (b) 1, 3 and 4
(c) 2, 3 and 4 (d) 1, 2 and 4

[ESE-2004]

(c) numerator polynomial of a closed-loop transfer function.
(d) denominator polynomial of a closed-loop transfer function.

[ESE-2016]

2.41 **Statement (I):** Open-loop system is inaccurate and unreliable due to internal disturbances and lack of adequate calibration.

Statement (II): Closed-loop system is inaccurate as it cannot account environmental or parametric changes and may become unstable.

Codes:
(a) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I).
(b) Both Statement (I) and Statement (II) are individually true but Statement (II) is not the correct explanation of Statement (I).
(c) Statement (I) is true but Statement (II) is false.
(d) Statement (I) is false but Statement (II) is true.

[ESE-2016]

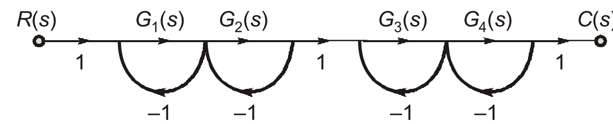
2.42 What is the open-loop transfer function for the system, whose characteristic equation is

$F(s) = s^3 + 3s^2 + (K+2)s + 5K = 0$?

(a) $G(s)H(s) = \dfrac{5K}{s(s+1)(s+3)}$
(b) $G(s)H(s) = \dfrac{Ks}{s(s+1)(s+2)}$
(c) $G(s)H(s) = \dfrac{K(s+5)}{s(s+1)(s+2)}$
(d) $G(s)H(s) = \dfrac{5K}{s(s+1)(s+2)}$

[ESE-2017]

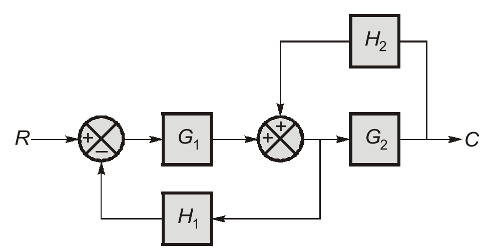
2.43 The closed-loop transfer function $C(s)/R(s)$ of the system represented by the signal flow graph as shown in figure is



(a) $\dfrac{G_1G_2G_3G_4}{(1+G_1+G_2)}$
(b) $\dfrac{G_1G_2G_3G_4}{(1+G_3+G_4)}$
(c) $\dfrac{G_1G_2G_3G_4}{(1+G_1+G_2)(1+G_3+G_4)}$
(d) $\dfrac{G_1G_2G_3G_4}{(1+G_1G_2)(1+G_3G_4)}$

[ESE-2018]

2.44 For the block diagram as shown in figure, the overall transfer function C/R is



(a) $\dfrac{G_1G_2H_1}{(1-G_1H_1-G_2H_2)}$ (b) $\dfrac{G_1G_2}{(1-G_1H_1+G_2H_2)}$
(c) $\dfrac{G_1G_2H_2}{(1+G_1H_1+G_2H_2)}$ (d) $\dfrac{G_1G_2}{(1+G_1H_1-G_2H_2)}$

[ESE-2018]

2.45 The steady state error of a type-1 system to a unit step input is

(a) $\dfrac{1}{(1+K_p)}$ (b) 0
(c) ∞ (d) $\dfrac{1}{K_v}$

[ESE-2019]

■■■■

Answers Block Diagram, Signal Flow Graph and Feedback Characteristics of Control Systems

2.1 (b)	2.2 (a)	2.3 (b)	2.4 (c)	2.5 (c)	2.6 (c)	2.7 (b)	2.8 (c)	2.9 (c)
2.10 (d)	2.11 (d)	2.12 (b)	2.13 (a)	2.14 (a)	2.15 (a)	2.16 (a)	2.17 (d)	2.18 (a)
2.19 (b)	2.20 (b)	2.21 (a)	2.22 (a)	2.23 (b)	2.24 (d)	2.25 (a)	2.26 (b)	2.27 (a)
2.28 (b)	2.29 (a)	2.30 (b)	2.31 (d)	2.32 (b)	2.33 (d)	2.34 (c)	2.35 (a)	2.36 (b)
2.37 (d)	2.38 (d)	2.39 (d)	2.40 (d)	2.41 (c)	2.42 (c)	2.43 (c)	2.44 (d)	2.45 (b)

Explanations Block Diagram, Signal Flow Graph and Feedback Characteristics of Control Systems

2.2 (a)

Transfer function is defined for linear systems, so superposition principle is applicable.

2.5 (c)

Forward path = *adfI*, *aefI*, *ahI*

Non touching loop pairs = (*fg* and *b*) one pair only.

2.7 (b)

$P = G_1G_2;\ P_2 = G_2G_3;\ \Delta_1 = \Delta_2 = 1$

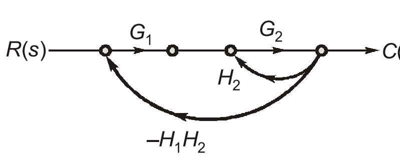
$L_1 = -G_1G_2H_1;\ L_2 = G_4;\ L_3 = -G_3G_2H_1$

$$\therefore \quad T(s) = \frac{P_1\Delta_1 + P_2\Delta_2}{1-(L_1+L_2+L_3)}$$

$$= \frac{G_1G_2 + G_2G_3}{1+G_1G_2H_1 + G_2G_3H_1 - G_4}$$

2.8 (c)

Making signal flow graph



$$\therefore \quad \frac{C(s)}{R(s)} = \frac{G_1G_2}{1-(G_2H_2 - G_1G_2H_1H_2)}$$

$$= \frac{G_1G_2}{1-G_2H_2 + G_1G_2H_1H_2}$$

2.11 (d)

Block diagram '*B*' can be obtained from '*A*' and '*C*' can be obtained from '*B*'.

2.13 (a)

$$T(s) = (G_1+G_3)\frac{G_2}{1+G_2H_1} = \frac{G_1G_2 + G_2G_3}{1+G_2H_1}$$

2.16 (a)

Speed of response is proportional to the bandwidth of the system. Higher the bandwidth faster the response.

2.18 (a)

Solving positive feed back

$$\text{T.F.} = \frac{G}{1-GF}$$

Now solving negative feed back path

$$\text{T.F}_1 = \frac{\frac{G}{1-GF}}{1+\frac{GH}{1-GF}}$$

$$\boxed{\text{T.F}_1 = \frac{G}{1-GF+GH}}$$

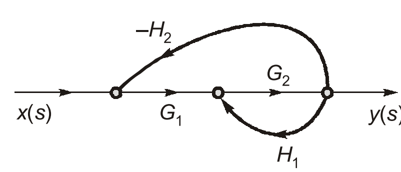
2.20 (b)

Only one loop and two path so using Mason's gain formula.

$$\frac{C(s)}{R(s)} = \frac{1+s^{-1}a}{1-(-bs^{-1})} = \frac{1+\frac{a}{s}}{1+\frac{b}{s}} = \frac{s+a}{s+b}$$

2.21 (a)

Making signal flow graph



$$\frac{y(s)}{x(s)} = \frac{G_1G_2}{1-(G_2H_1 - G_1G_2H_2)}$$

$$= \frac{G_1G_2}{1-G_2H_1 + G_1G_2H_2}$$