



Zeal Education Society's
ZEAL POLYTECHNIC, PUNE.

NARHE | PUNE -41 | INDIA

THIRD YEAR (TY)

DIPLOMA IN E&TC ENGINEERING

SCHEME: I

SEMESTER: V

NAME OF SUBJECT: CONTROL SYSTEMS & PLC

Subject Code: 22530

MSBTE QUESTION PAPERS & MODEL ANSWERS

1. MSBTE SAMPLE QUESTION PAPER

2. MSBTE WINTER-19 EXAMINATION

Scheme – I

Sample Question Paper

Program Name : Electronics Engineering Programme Group
Program Code : DE/EJ/ET/EN/EX/EQ
Semester : Fifth
Course Title : Control Systems and PLC
Marks : 70

22531

Time: 3 Hrs.

Instructions:

- (1) All questions are compulsory.
- (2) Illustrate your answers with neat sketches wherever necessary.
- (3) Figures to the right indicate full marks.
- (4) Assume suitable data if necessary.
- (5) Preferably, write the answers in sequential order.

Q.1) Attempt any FIVE of the following: -

10 Marks

- (a) Draw electrical symbol used to represent NO pushbutton, NC pushbutton.
- (b) Define: Stable system and marginally stable system.
- (c) Give two practical examples of: i) Open loop system ii) Closed loop system.
- (d) Define following terms with respect to PLC
 - i. Scan time
 - ii. Speed of execution
- (e) Find order of system for the unity feedback system with

$$C(s) = \frac{16}{s(s+8)}$$

- (f) Compare Linear and non-linear system on the basis of additive property and homogeneous property.
- (g) Find the output of derivative controller mode if error is zero.

Q.2) Attempt any THREE of the following: -

12 Marks

- (a) Give any four rules for block diagram reduction technique.
- (b) Illustrate Proportional- Derivative control(PD) action with output Equation and nature of output response
- (c) Draw and describe the block diagram of AC discrete output module of PLC.
- (d) Name any four input and output devices which can be interfaced with PLC.

Q.3) Attempt any THREE of the following.

12 Marks

- (a) Transfer function of a second order system is given by

$$\frac{C(s)}{R(s)} = \frac{64}{s^2 + 5s + 64}$$

Find

- Natural frequency of oscillation
 - Damping Ratio
 - Peak Time
 - Settling Time
- (b) State four points of information associated with a counter instruction of PLC.
- (c) Draw block diagram of PLC and give the function of isolator used in it.
- (d) Plot a graph of proportional-Integral (PI) controller mode output as a function of time for the given error in figure-1. $K_P=5$, $K_I=1.0 \text{ S}^{-1}$ and $P_I(0) = 20\%$.

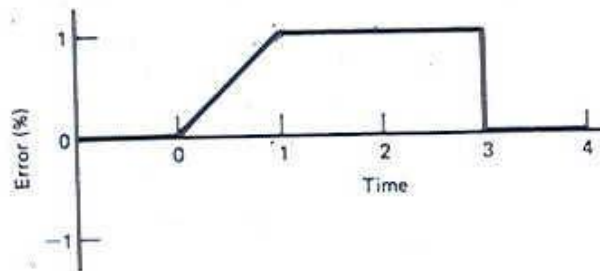


Figure-1

Q.4) Attempt any THREE of the following.

12 Marks

- (a) Justify 'Modular PLCs are preferable in automation industry.
- (b) Draw and describe Proportional band in Proportional controller mode.
- (c) List the different types of standard test input signals to test the control system. Also give their Laplace transform with sketch.
- (d) Derive transfer function for the system given in figure-2:

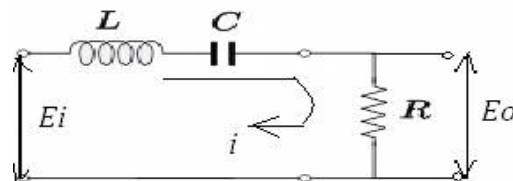


Figure-2

- (e) Describe sinking and sourcing concept in DC input modules of PLC

Q.5) Attempt any TWO of the following.**12 Marks**

(a) For unity feedback system with

$$G(s) = \frac{5(s+1)}{s^2(s+3)(s+10)}$$

Find type of system, static error coefficient and steady state Error when input to the

system is $r(t) = 1 + 3t + \frac{t^2}{2}$

(b) With respect to PLC

- i. State the importance of PLC in automation
- ii. Describe memory organization of PLC.

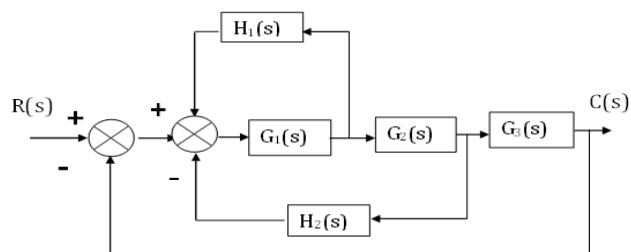
(c) Draw ladder diagram for 3 motor operation for following conditions

- i. Start push button starts motors M1 and
- ii. after 10 seconds motor M2 starts and
- iii. after 10 seconds motor M3 starts

Q.6) Attempt any TWO of the following.**12 Marks**

(a) Draw the ladder diagram to verify : AND gate , NAND Gate and NOR Gate logic

(b) Obtain transfer function for the system given in figure -3,using block diagram reduction technique

**Figure-3**

(c) State the Routh's criterion and describe two special cases of Rouths criterion with example

Scheme – I

Sample Test Paper - I

Program Name : Electronics Engineering Programme Group
Program Code : DE/EJ/ET/EN/EX/EQ
Semester : Fifth
Course Title : Control Systems and PLC
Marks : 20

22531

Time: 1 Hour.

Instructions:

- (1) All questions are compulsory.
- (2) Illustrate your answers with neat sketches wherever necessary.
- (3) Figures to the right indicate full marks.
- (4) Assume suitable data if necessary.
- (5) Preferably, write the answers in sequential order.

Q.1 Attempt any FOUR.

08 Marks

- (a) Define following terms with respect to controller –
 - i. Offset error
 - ii) Proportional band.
- (b) For time response of second order system state formula for:
 - i. Rise time
 - ii) Settling time
- (c) Compare Open Loop and Closed Loop Control system based on Transfer function and Stability.
- (d) Give the values of damping ratio for critically damped system and over damped system.
- (e) Draw the block diagram of DC Servo System.

Q.2 Attempt any THREE.

12 Marks

- (a) Define transfer function. Derive an expression for transfer function of simple closed loop system.
- (b) For a unity feedback system having open loop transfer function

$$G(s) = \frac{K(s+2)}{s(s^3 + 7s^2 + 12s)}$$

Determine:

- i) Type of system
- ii) Error constant K_p , K_v and K_a
- (c) Find the range of values of K so that system with following characteristic equation will be stable: $s^4 + 5s^3 + 5s^2 + 4s + k = 0$
- (d) Describe Neutral zone in ON-OFF controller mode.

Scheme – I

Sample Test Paper - II

Program Name : Electronics Engineering Programme Group
Program Code : DE/EJ/ET/EN/EX/EQ
Semester : Fifth
Course Title : Control Systems and PLC
Marks : 20

22531

Time: 1 Hour.

Instructions:

- (1) All questions are compulsory.
- (2) Illustrate your answers with neat sketches wherever necessary.
- (3) Figures to the right indicate full marks.
- (4) Assume suitable data if necessary.
- (5) Preferably, write the answers in sequential order.

Q.1 Attempt any FOUR.

08 Marks

- (a) List out functions of PLC output module.
- (b) List two types of PLC programming devices
- (c) Explain the terms normally open and normally closed contact.
- (d) Draw PLC Scan Cycle.
- (e) List any four compare instructions of PLC.

Q.2 Attempt any THREE.

12 Marks

- (a) State stepwise procedure of PLC installation.
- (b) Draw the ladder diagram to verify:
 - i) OR gate ii) NOR Gate logic.
- (c) Draw the block diagram of AC discrete input module of PLC.
- (d) Illustrate Proportional-Integral (PI) control action with output Equation and nature of output response

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11920

3 Hours / 70 Marks

Seat No.

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- Instructions* – (1) All Questions are *Compulsory*.
- (2) Answer each next main Question on a new page.
- (3) Illustrate your answers with neat sketches wherever necessary.
- (4) Figures to the right indicate full marks.
- (5) Assume suitable data, if necessary.
- (6) Use of Non-programmable Electronic Pocket Calculator is permissible.
- (7) Mobile Phone, Pager and any other Electronic Communication devices are not permissible in Examination Hall.

Marks

1. **Attempt any FIVE of the following:** **10**

- a) List any four names of PLC programming languages.
- b) Define transient response and steady state response for any system.
- c) Calculate the order of following system.
- $$G(S) = \frac{(S + 2)(S + 5)}{S(S + 3)(S + 4)}$$
- d) List two inputs and two output devices of PLC.
- e) Sketch and label the time response for second order system.
- f) Draw the general block diagram of closed loop control system.
- g) Draw electronic PI controller using Op-amp.

P.T.O.

- 2. Attempt any THREE of the following:** **12**
- a) State any four block diagram reduction rules with neat diagram.
 - b) Draw neat block diagram of process control system.
 - c) Describe Discrete AC output modules of PLC with the help of neat diagram.
 - d) Illustrate the steps for PLC Installation.
- 3. Attempt any THREE of the following:** **12**
- a) Discuss the special cases of Routh's Criterion.
 - b) Draw the PLC ladder diagram for 2 input OR logic gate.
 - c) Draw labeled block diagram of PLC.
 - d) Elaborate ON - OFF controller with suitable example. State significance of neutral zone.
- 4. Attempt any THREE of the following:** **12**
- a) Classify Fixed and Modular PLC.
 - b) Describe PID controller with neat diagram, output equation and response.
 - c) Define the following terms related to second order system.
 - (i) Damping
 - (ii) Damping Ratio
 - (iii) Undamped Natural Frequency.
 - (iv) Damped Frequency.
 - d) Describe Linearity Property and Change of Scale Property of Laplace Transform.
 - e) Describe Relay instruction for PLC.

5. Attempt any TWO of the following:

12

- a) For a unity feedback control system

$$G(S) = \frac{100(S + 2)}{S^2}$$

Calculate all the Error constants.

- b) Describe Operating cycle of PLC with neat diagram.
c) Develop a ladder diagram for 4:1 Multiplexer

6. Attempt any TWO of the following:

12

- a) Illustrate PLC Timer in detail.
b) Apply the block diagram reduction rules to obtain Transfer Function $C(S) / R(S)$ of the following block diagram.
(Refer Figure No. 1)

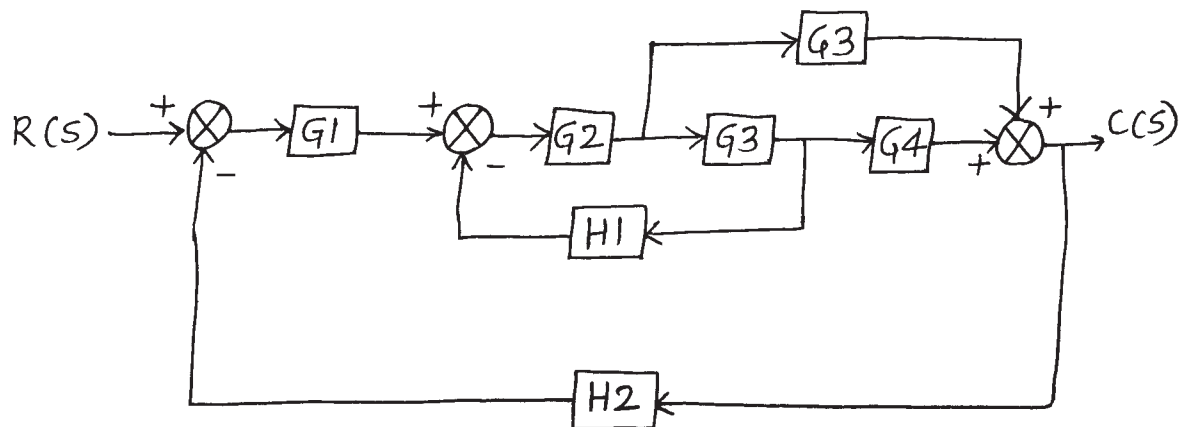


Figure No. 1

- c) Describe four standard test inputs with their mathematical expression and Graphical Representation.



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Subject Name: Control System and PLC Model Answer Subject Code:

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Important Instructions to examiners:

- 1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
- 2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
- 3) The language errors such as grammatical, spelling errors should not be given more importance (Not applicable for subject English and Communication Skills).
- 4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
- 5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
- 6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
- 7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q. No.	Sub Q. N.	Answers	Marking Scheme
1	(A)	Attempt any FIVE of the following:	10- Total Marks
	(a)	List any four names of PLC programming languages.	2M
	Ans:	1) Ladder diagram programming 2) Instruction list programming 3) Structured text programming 4) Function block diagram programming 5) Sequential function charts	Any four: 2M
	(b)	Define transient response and steady state response for any system.	2M
	Ans:	Transient response: The output variation during the time, it takes to achieve its final value is called transient response. Steady state response: It is that part of the time response which remains after complete transient response vanishes from the system output	Definition : 1M each

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Subject Name: Control System and PLC Model Answer Subject Code:

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	OR	
	It is defined as the response of the system as time approaches infinity from the time at which transient response completely dies out.	
(c)	Calculate the order of following system. $G(s) = \frac{(S+2)(S+5)}{S(S+3)(S+4)}$	2M
Ans:	$G(s) = \frac{(S+2)(S+5)}{S(S+3)(S+4)}$ $G(s) = \frac{(S+2)(S+5)}{(S+4)(S^2+3S)}$ $G(s) = \frac{(S+2)(S+5)}{(S^3+7S^2+12S)}$ <p>Highest power of 'S' in denominator is 3 Therefore, Order of the system is 3.</p>	Order : 2M
(d)	List two inputs and two output devices of PLC.	2M
Ans:	<p>Input devices:</p> <ol style="list-style-type: none"> 1) Mechanical switches 2) Proximity switches 3) Photoelectric switches 4) Encoders <p>Output devices:</p> <ol style="list-style-type: none"> 1) Contactors 2) Relays 3) Motors 4) Lights 	<p>Any two inputs : 1M</p> <p>Any two outputs : 1M</p>
e)	Sketch and label the time response for second order system.	2M

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3

Ans:

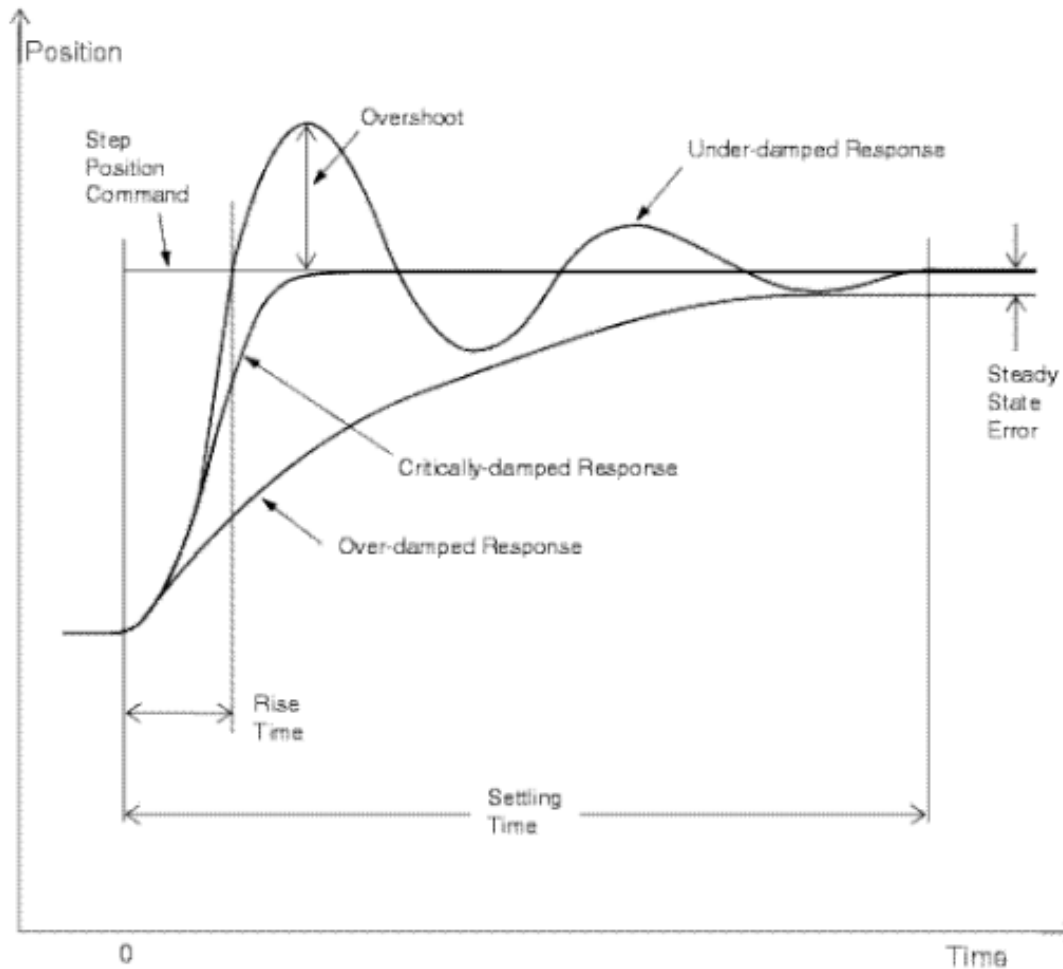


Diagram
: 2M

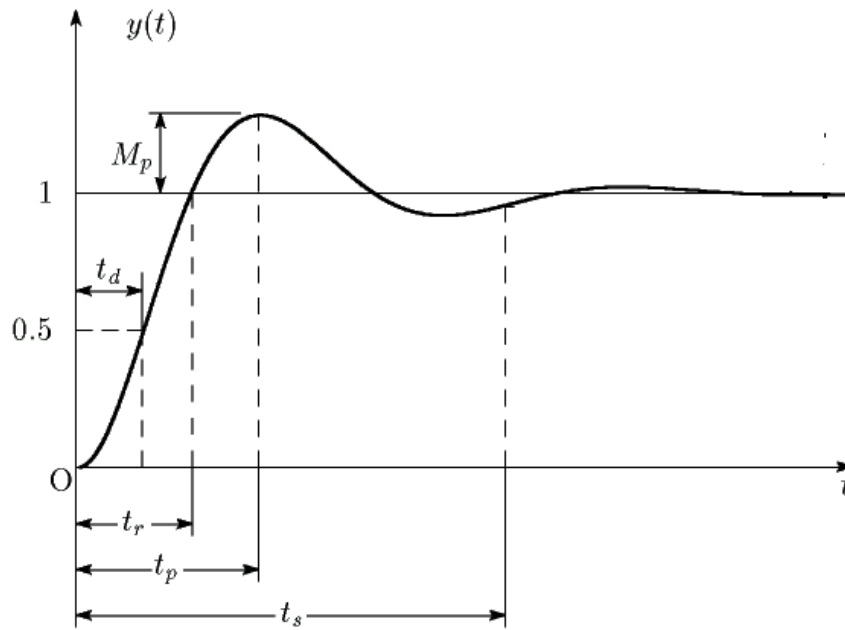
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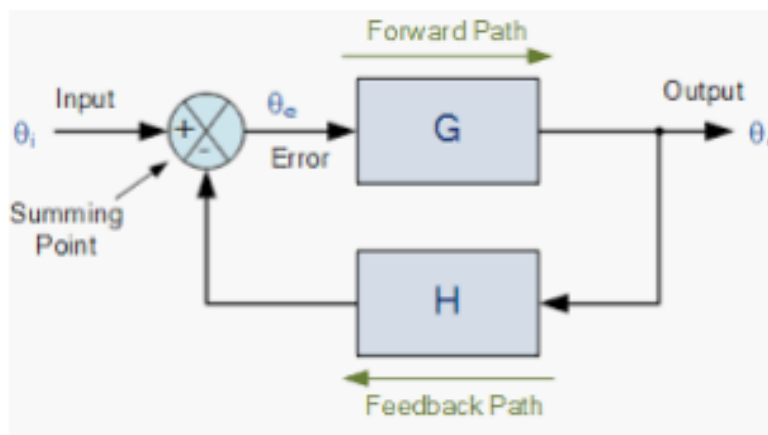
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f) Draw the general block diagram of closed loop control system.

2M

Ans:



Or

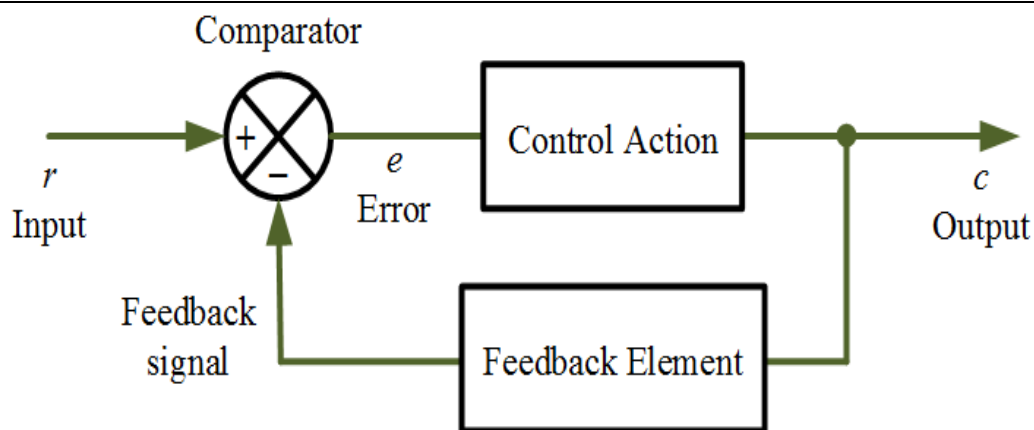
Diagram
: 2M

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g) Draw electronic PI controller using Op-amp.

2M

Ans:

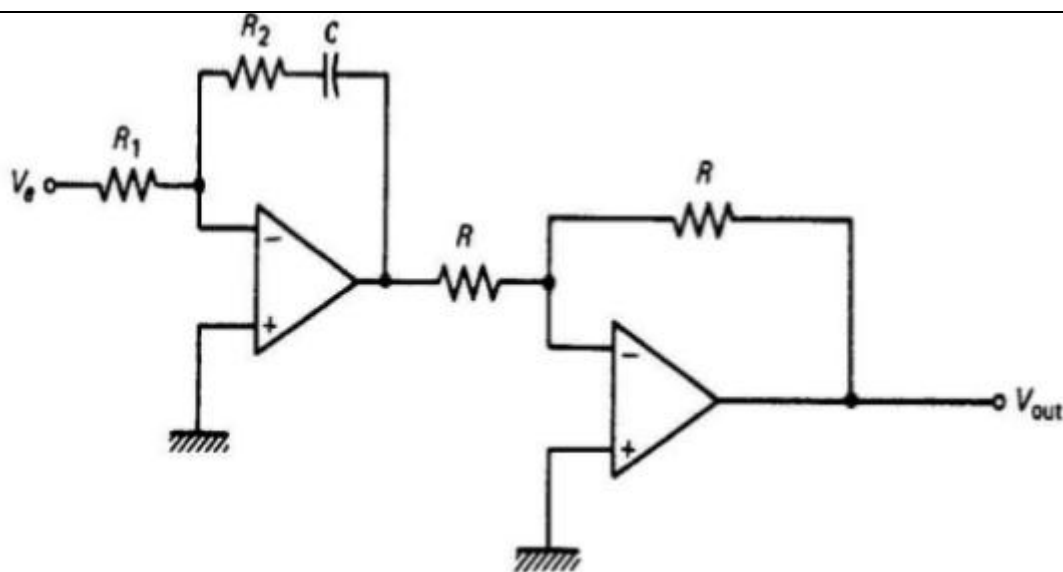


Diagram
: 2M

Q. No.	Sub Q. N.	Answers	Marking Scheme
2		Attempt any THREE of the following:	12- Total Marks
	a)	State any four block diagram reduction rules with neat diagram.	4M

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Subject Name: Control System and PLC Model Answer Subject Code:

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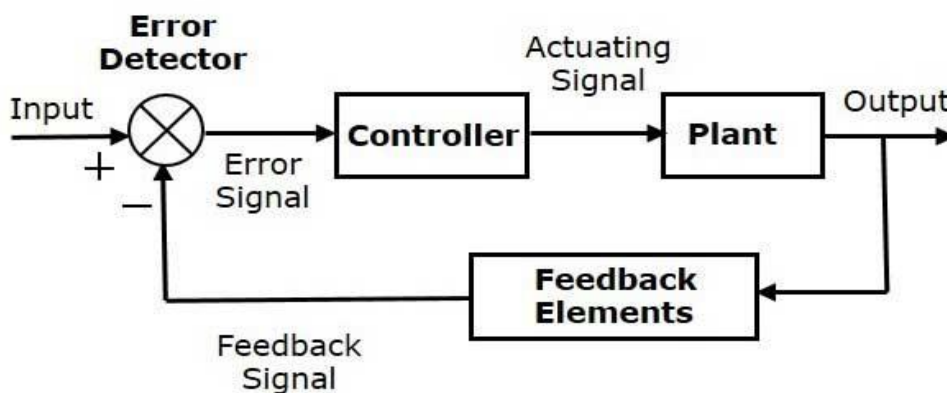
<p>Ans:</p>	<table> <tr> <th data-bbox="220 317 558 373">Manipulation</th><th data-bbox="558 317 907 373">Original Block Diagram</th><th data-bbox="907 317 1370 373">Equivalent Block Diagram</th></tr> <tr> <td data-bbox="220 373 558 543">Combining Blocks in Cascade</td><td data-bbox="558 373 907 543"></td><td data-bbox="907 373 1370 543"></td></tr> <tr> <td data-bbox="220 543 558 714">Combining Blocks in Parallel; or Eliminating a Forward Loop</td><td data-bbox="558 543 907 714"></td><td data-bbox="907 543 1370 714"></td></tr> <tr> <td data-bbox="220 714 558 884">Moving a pickoff point behind a block</td><td data-bbox="558 714 907 884"></td><td data-bbox="907 714 1370 884"></td></tr> <tr> <td data-bbox="220 884 558 1033">Moving a pickoff point ahead of a block</td><td data-bbox="558 884 907 1033"></td><td data-bbox="907 884 1370 1033"></td></tr> <tr> <td data-bbox="220 1033 558 1182">Moving a summing point behind a block</td><td data-bbox="558 1033 907 1182"></td><td data-bbox="907 1033 1370 1182"></td></tr> <tr> <td data-bbox="220 1182 558 1461">Moving a summing point ahead of a block</td><td data-bbox="558 1182 907 1461"></td><td data-bbox="907 1182 1370 1461"></td></tr> </table>	Manipulation	Original Block Diagram	Equivalent Block Diagram	Combining Blocks in Cascade			Combining Blocks in Parallel; or Eliminating a Forward Loop			Moving a pickoff point behind a block			Moving a pickoff point ahead of a block			Moving a summing point behind a block			Moving a summing point ahead of a block			<p>Any four rules : 4M</p>
Manipulation	Original Block Diagram	Equivalent Block Diagram																					
Combining Blocks in Cascade																							
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Moving a pickoff point ahead of a block																							
Moving a summing point behind a block																							
Moving a summing point ahead of a block																							
<p>b)</p>	<p>Draw neat block diagram of process control system.</p>	<p>4M</p>																					
<p>Ans:</p>	<p>Automatic controller</p> <p>OR</p>	<p>Block Diagram -4M</p>																					

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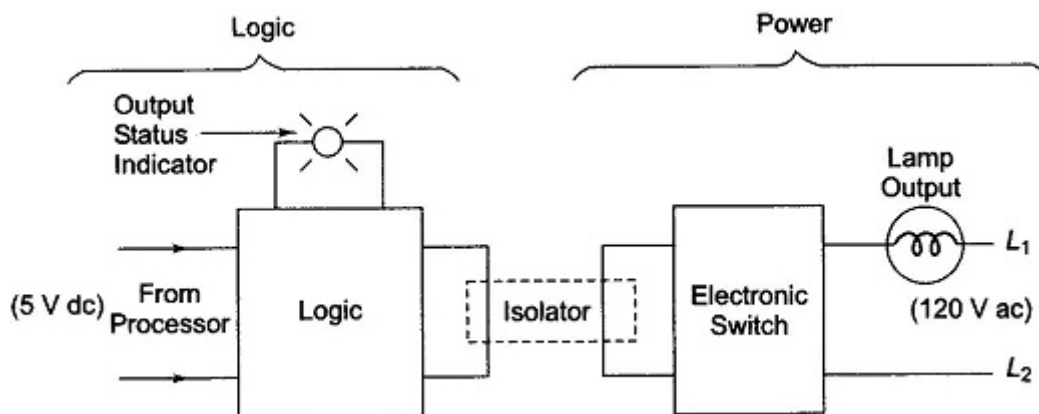


NOTE: Any relevant diagram must be considered

c) Describe discrete AC output modules of PLC with the help of neat diagram.

4M

Ans: Block diagram of discrete AC output module



It is composed of two basic sections, the power section and the logic section, coupled by an isolation circuit. The output interface can be considered of as a simple electronic switch to which power is applied to control output device.

A simplified schematic and wiring diagram for one output of a typical ac output module is shown in Fig.

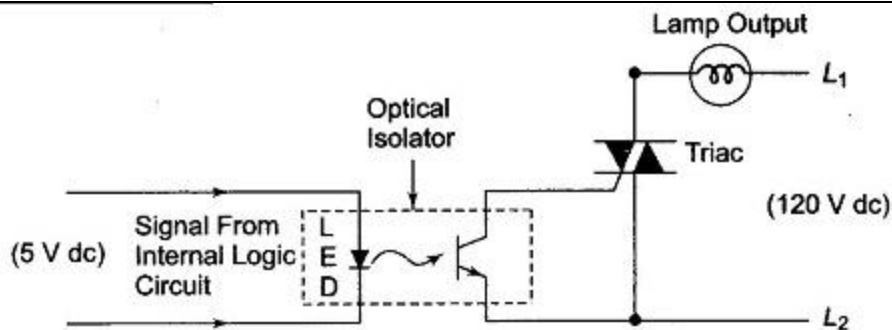
Block diagram : 1M
schematic diagram : 1M
Description : 2M

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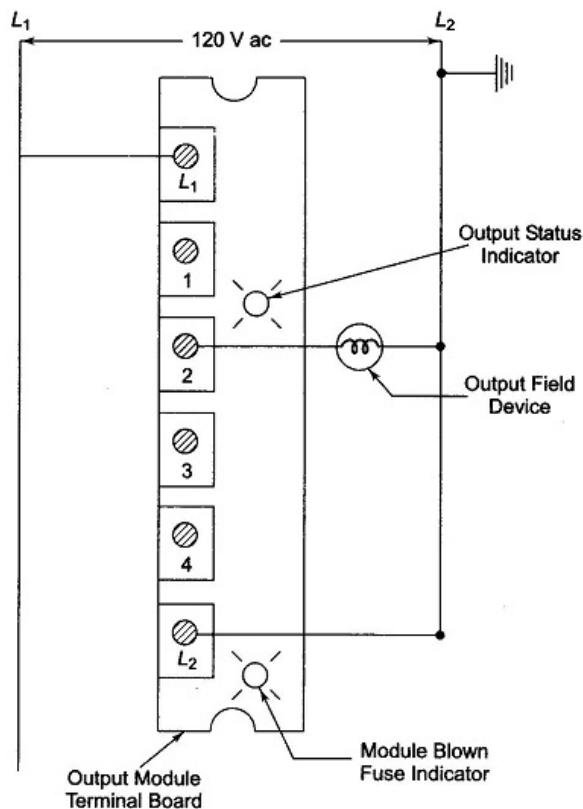
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Simplified Schematic of an ac Output Module



Typical Output Module Wiring Connection

As part of its normal operation, the processor sets the output states according to the logic program. When the processor calls for an output, a voltage is applied across the LED of the isolator. The LED then emits light which switches on the phototransistor into conduction. This, in turn, switches a semiconductor switch such as Triac into conduction which turns on the lamp. Since the triac conducts in either direction, the output to lamp is ac.

The triac rather than having ON and OFF status, actually has low and high resistance levels respectively. In its OFF state (high resistance) a small leakage current of a few mA still flows

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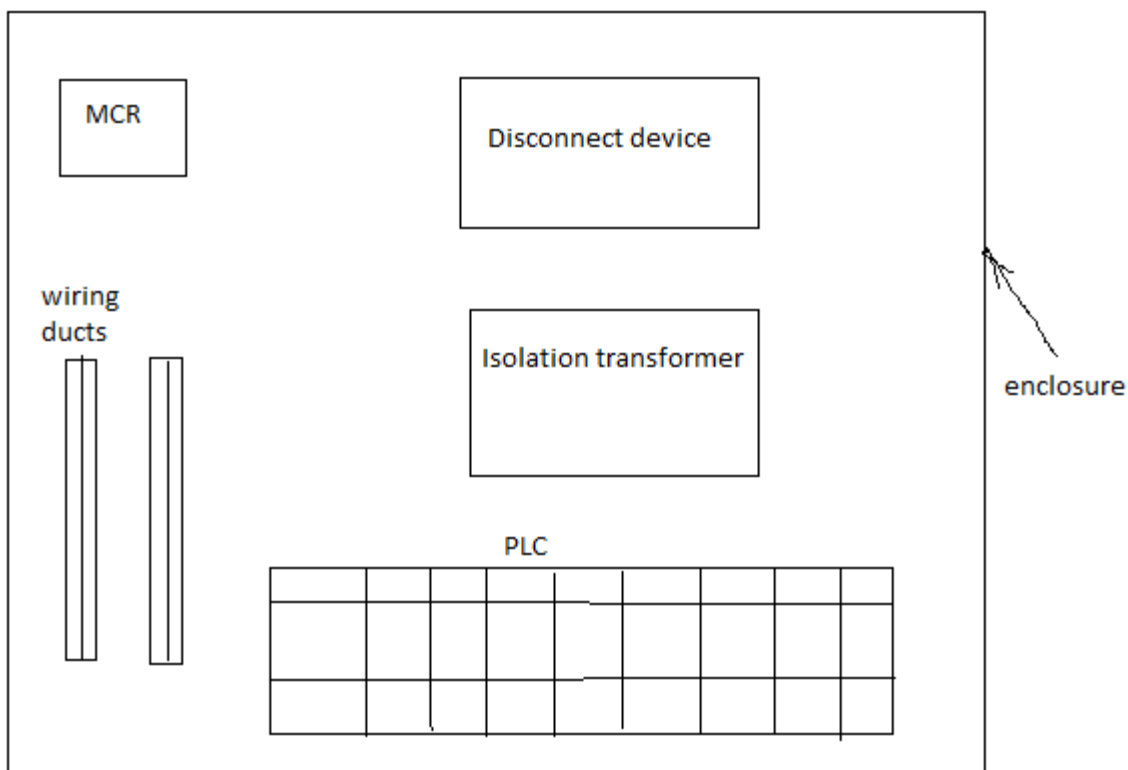
through the triac. As with input circuits, the output interface is usually provided with LED's that indicate the status of each output

d) Illustrate the steps for PLC installation.

4M

Ans:

Steps :
4M



The following parameters should be considered while installing the PLC,

1) **Enclosure :**

It is a metal or non- metal cabinet to fix the PLC and its supporting devices. It provides enough space between PLC and other components for air circulation to maintain temperature between 0 ° to 55° C. if the temperature exceeds 55°C the provide cooling fan. Install PLC away from high voltage equipments.

2) **Disconnect device:**

The enclosure should have power disconnect. So that, when required the PLC can be worked on with power OFF.

3) **MCR:**

Master control relay is used to interrupt power to the I/O rack in the event of a system failure.

4) **Isolation transformer:**



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Subject Name: Control System and PLC Model Answer Subject Code:

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- Provides physical isolation from the main power distribution.
- 5) When PLC is operated in noise polluted environment, then noise suppressors should be used.
- 6) Proper grounding is an important measure in PLC installation.

Q. No.	Sub Q. N.	Answers	Marking Scheme
3		Attempt any THREE of the following :	12- Total Marks
	a)	Discuss the special cases of Routh's criterion.	4M

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<p>Ans:</p>	<p>Special case 1</p> <ol style="list-style-type: none"> 1) Statement – First element of any of the rows of Routh's array is zero & the same remaining rows contains at least one non zero element. 2) Effect-The terms in the next row become infinite and Routh's test fails. 3) Solution for this said difficulty-Substitute a small positive number 'ϵ' in place of a zero occurred as a first element in a row and complete the array with this number 'ϵ'. Then examine the sign change by taking $\lim_{\epsilon \rightarrow 0}$. <p>Special case 2</p> <ol style="list-style-type: none"> 1) Statement-All the elements of a row in a Routh's array are zero. 2) Effect-The terms of the next row cannot be determined & Routh's test fails. 3) Solution for this said difficulty- <ol style="list-style-type: none"> (i) Form an equation by using the coefficients of a row which is just above the row of zeros. Such an equation is called as auxiliary equation denoted as $A(s)$. (ii) Take the derivative of an auxiliary equation with respect to 's' (iii) Replace row of zeros by the coefficients of $dA(s)/ds$. (iv) Complete the array in terms of these new coefficients & by observing the first column of Routh's array state the stability of the system <p>Note: Marks can be given for relevant explanation too</p>	<p>for each case : 2M</p>
<p>b)</p>	<p>Draw the PLC ladder diagram for two input OR logic gate.</p>	<p>4M</p>

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Ans:

OR:

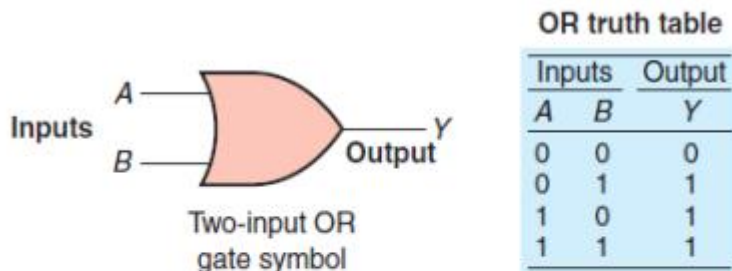
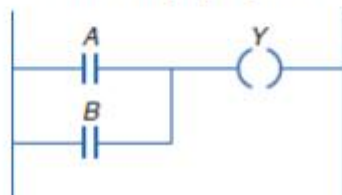


Fig. The OR gate symbol and truth table

Ladder logic program



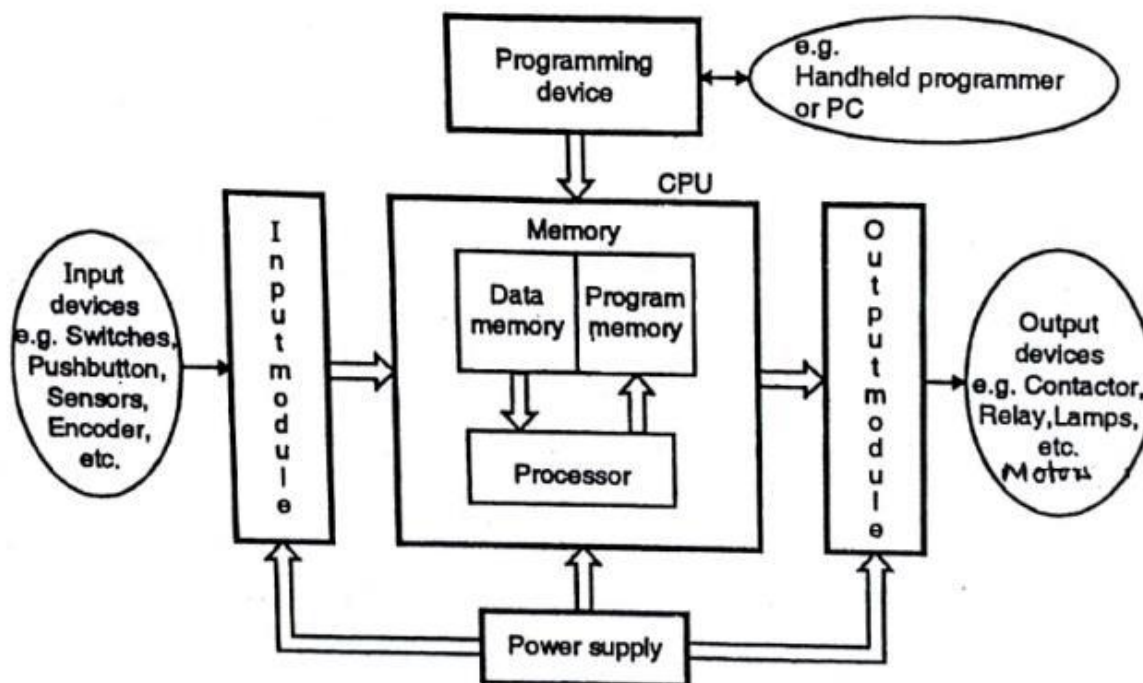
Ladder diagram : 4M

c)

Draw labeled block diagram of PLC.

4M

Ans:



Block diagram of PLC

Block diagram :4M



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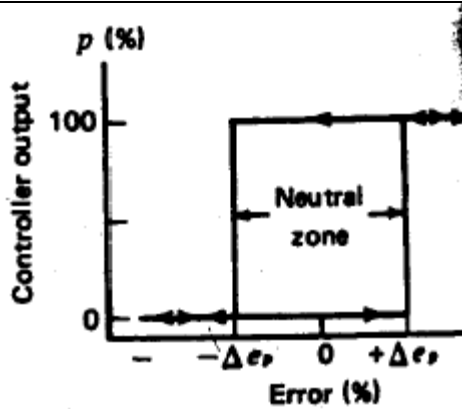
d)	Elaborate ON – OFF controller with suitable example. State significance of neutral zone.	4M
Ans:	<p>ON – OFF controller :</p> <p>ON – OFF controller has only two positions either it is fully closed or fully open. This control element does not operate at any intermediate position, i.e. partly open or partly closed position. The control system made for controlling such elements is known as on off control theory. In this control system, when process variable changes and crosses certain preset level, the output valve of the system is suddenly fully opened and gives 100 % output. Generally in on off control system, the output causes change in process variable. Hence due to effect of output, the process variable again starts changing but in reverse direction. During this change, when process variable crosses certain predetermined level, the output valve of the system is immediately closed and output is suddenly reduced to 0%.</p> <p>As there is no output, the process variable again starts changing in its normal direction. When it crosses the preset level, the output valve of the system is again fully open to give 100% output. This cycle of closing and opening of output valve continues till the said on-off control system is in operation.</p> <p>A common example of on-off control is the temperature control in a domestic heating system. When the temperature is below the thermostat set point the heating system is switched on and when the temperature is above the set point the heating switches off.</p> <p>Significance of Neutral zone :</p> <p>In any practical implementation of the two – position controller, there is an overlap as e_p increases through zero or decreases through zero. In this span, no change in controller output occurs. It is called Neutral zone.</p> <p>Fig shows p versus e_p for ON-OFF Controller. Until an increasing error changes by Δe_p above zero, the controller output will not change state. In decreasing it must fall Δe_p below zero before the controller changes to the 0% rating.</p>	<p>Explanation : 2M</p> <p>Significance: 2M</p>

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Q. No.	Sub Q. N.	Answers		Marking Scheme	
4		Attempt any THREE of the following :		12- Total Marks	
	(a)	Classify Fixed and Modular PLC.		4M	
	Ans:	Sr. No	Fixed PLC	Modular PLC	Any four points :4M
		1	It is also known as an integrated PLC or Compact PLC.	It is also known as rack-mounted units.	
		2	In Fixed PLC, the number of inputs and outputs are fixed because I/O capabilities are decided by the manufacturer but not by the user.	In Modular PLC, the number of inputs and outputs are not fixed. Inputs outputs can be added to the modular PLC systems by the user.	
		3	It has inputs and outputs modular fitted with CPU.	In this PLC, several components are fitted on chassis or rack or bus with different slots.	
		4	Fixed PLC is not easily repaired.	Modular PLC is easy to maintain and repair as compared to fixed PLC.	

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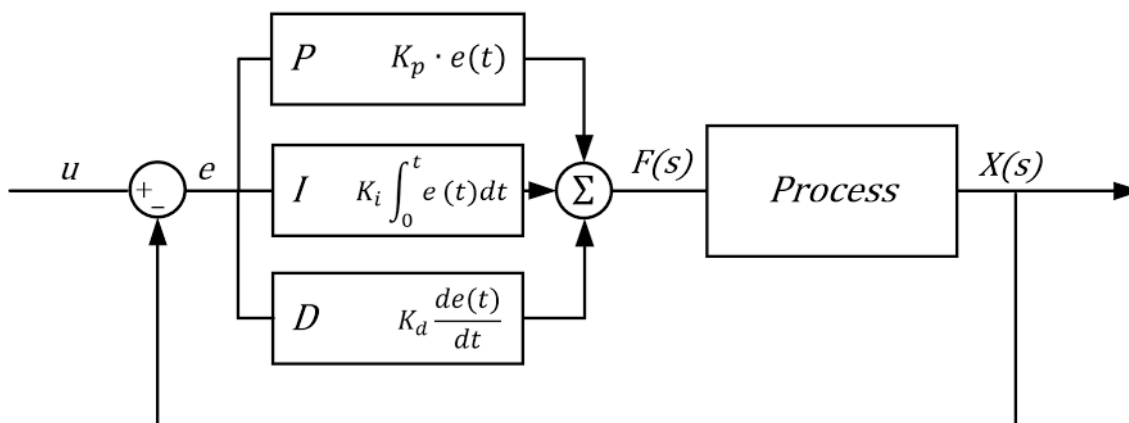
5	It has fewer capabilities to store data/information.	It has more memory and capabilities to store more data.
6	It is useful for the smaller applications and most suitable for the domestic purpose.	It is used for industrial purpose and also for future industrial expansion and growth.
7	It is smaller in size.	It occurs in a large size with i/o connectivity, power supply, computing capabilities, etc.
8	It is an economic model.	It is costlier than Fixed PLC.

(b) Describe PID controller with neat diagram, output equation and response.

4M

Ans: PID controller

Diagram : 2M



Note: Any other relevant diagram should be considered

Explanation:

- The combination of proportional control action, derivative control action and integral control action is called as PID controller action.
- The combined action has advantage of the three individual control actions. The proportional controller stabilizes gain but produces steady state error.
- The integral action reduces the steady state error. The derivative action reduces the rate of change of error.
- PID controller is a band pass or band attenuate filter, depending on the values of the controller parameters.
- The response characteristics of PID controller is shown in figure. The proportional part of

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the control action repeats the change of deviation.

vi) The derivative action of the control action adds on increment of manipulated variables so that the proportional plus derivative control action is shifted ahead in time.

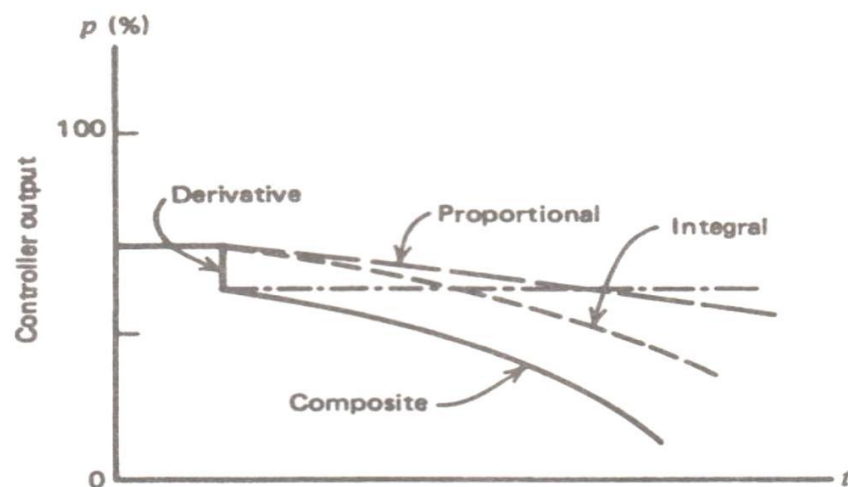
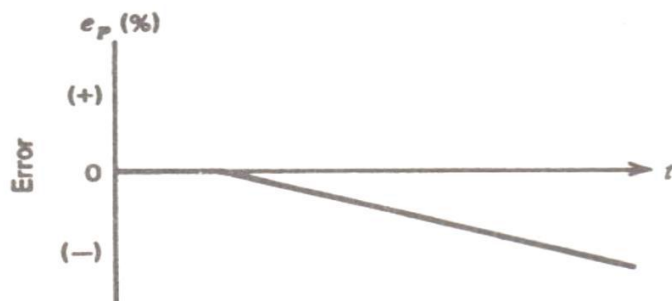
vii) The integral part of the control action adds a further increment of manipulated variable.

Output equation:

$$P = K_P E_P + K_P K_I \int E_P dt + K_P K_D \frac{dE_P}{dt} + P_I(0)$$

Nature of output response to error:

(Note: Response with respect to any other error can be considered)



Explanat
ion : 1M

Equatio
n : 1M

Respons
e : 1M

(c) Define the following terms related to second order system.

- (i) Damping
- (ii) Damping ratio
- (iii) Undamped natural frequency

4M



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	(iv) Damped frequency	
Ans:	<p>(i) Damping : Every system has tendency to oppose the oscillatory behavior of the system which is called as damping .</p> <p>(ii) Damping ratio : The damping is measured by a factor or a ratio called damping ratio of the system</p> <p>(iii) Undamped natural frequency : Natural frequency is basically the frequency with which any oscillations takes place with no damping</p> <p>(iv) Damped frequency : It is the frequency at which a Damped system oscillates when not subjected to a continuous or repeated external force. It is given by formula :</p> $\omega_d = \omega_n \sqrt{1 - \zeta^2}$ $\zeta = \text{damping ratio}$ $\omega_d = \text{damped frequency}$ $\omega_n = \text{natural frequency}$	<p>Definition : 1M each</p>
(d)	Describe linearity property and change of scale Property of Laplace Transform.	4M
Ans:	<p>Linearity Property :</p> <p>The linearity property of the Laplace Transform states:</p> $a \cdot f(t) + b \cdot g(t) \xrightarrow{\mathcal{L}} a \cdot F(s) + b \cdot G(s)$ <p>This is easily proven from the definition of the Laplace Transform</p> $\mathcal{L}(a \cdot f(t) + b \cdot g(t)) = \int_{0^-}^{\infty} (a \cdot f(t) + b \cdot g(t)) e^{-st} dt$ $= a \int_{0^-}^{\infty} f(t) e^{-st} dt + b \int_{0^-}^{\infty} g(t) e^{-st} dt$ $= a \cdot F(s) + b \cdot G(s)$	<p>Linearity property : 2M</p> <p>Change of scale property : 2M</p>

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Change of Scale Property :-

If $L[f(t)] = F[s]$ then,

$$L[f(at)] = \frac{1}{a} F\left[\frac{s}{a}\right]$$

→ By definition of Laplace Transform,

$$L[f(t)] = \int_0^{\infty} e^{-st} f(t) dt \rightarrow (1)$$

$$\therefore L[f(at)] = \int_0^{\infty} e^{-st} f(at) dt$$

$$\text{Put } at = u \quad \therefore t = \frac{u}{a}$$

$$\frac{dt}{du} = \frac{1}{a} \quad \therefore dt = \frac{1}{a} du$$

$$\begin{aligned} \therefore L[f(at)] &= \int_0^{\infty} e^{-\frac{s}{a}u} f(u) \frac{1}{a} du \\ &= \frac{1}{a} \int_0^{\infty} e^{-\left(\frac{s}{a}\right)u} f(u) du \end{aligned}$$

$$\boxed{\therefore L[f(at)] = \frac{1}{a} F\left[\frac{s}{a}\right]} \quad (\text{from (1)})$$

(e) Describe Relay instructions for PLC.

4M

Ans:

Relay type instructions

1. Normally open (XIC)
2. Normally closed (XIO)
3. One shot instruction(OSR)
4. Output instruction
5. Output latch instruction(L)
6. Output unlatch instruction(U)

Explanation:

1. Normally open (XIC) :

Descript
ion : 4M

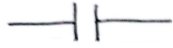
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Symbol :



When the contact is switched ON, the circuit is completed and current flows through the circuit.

2. Normally Close (XIO) :

Symbol :



When the contact is switched ON, the circuit is broken and the current flowing through the circuit stops.

3. One Shot Instruction (OSR) :

Symbol :



If the conditions of rung before OSR instruction are true or satisfied then OSR instruction is true for one scan cycle and also triggers o/even if rung conditions are still true.

4. Output Instruction :

Symbol :



It becomes ON if the process finds true path in the rung containing this


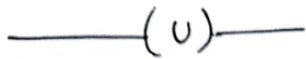


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		<p>o/p otherwise it remains OFF.</p> <p>5. Output latch instruction(L) :</p> <p>Symbol :</p>  <p>It is a latch type coil of the output. It is set to 1 when input becomes true for one input scan output stay ON even if input goes false.</p> <p>6. Output unlatch instruction(U) :</p> <p>Symbol :</p>  <p>It is a latch type coil of the output. It is used to reset or unlatch the latched coil if the input become true or 1 for one input scan.</p>	
Q. No.	Sub Q. N.	Answers	Marking Scheme
5.		Attempt any TWO of the following:	12- Total

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			Marks
a)	<p>For unity feedback control system</p> $G(s) = \frac{100 (S+2)}{s^2}$ <p>Calculate all error constants.</p>	6M	
Ans:	<p><u>Q5 a)</u> $G(s) = \frac{100 (s+2)}{s^2}$</p> <p>Converting this into standard form,</p> $G(s) = \frac{100 \times 2 \left(\frac{s}{2} + 1\right)}{s^2}$ $G(s) = \frac{200 (1 + 0.5s)}{s^2}$ <p>Positional error coefficient $K_p = \lim_{s \rightarrow 0} G(s) \cdot H(s)$</p> $K_p = \lim_{s \rightarrow 0} \frac{200 (1 + 0.5s)}{s^2} = \infty$ <p>Velocity error coefficient $K_v = \lim_{s \rightarrow 0} s \cdot G(s) \cdot H(s)$</p> $K_v = \lim_{s \rightarrow 0} \frac{s \cdot 200 (1 + 0.5s)}{s^2} = \infty$ <p>Acceleration error coefficient $K_a = \lim_{s \rightarrow 0} s^2 \cdot G(s) \cdot H(s)$</p> $K_a = \lim_{s \rightarrow 0} \frac{s^2 \cdot 200 (1 + 0.5s)}{s^2} = 200$ <div>$K_p = \infty, K_v = \infty$ $K_a = 200$</div>	2M for each error coefficient	
b)	<p>Describe Operating cycle of PLC with neat diagram.</p>	6M	
Ans:	<div><pre>graph TD A[INPUT SCAN] --> B[PROGRAM SCAN] B --> C[OUTPUT SCAN] C --> A</pre></div> <p>The scan cycle consist of three steps.</p> <p>Input scan, program scan and output scan.</p>	<p>Diagram : 2M</p> <p>Explanati on : 4M</p>	

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PLC checks ON or OFF status of each input point connected to the module. This information is stored in input status file.

Then CPU starts executing user program left to right and top to bottom from the first instruction to the last. It updates the output status file depending on the program.

In the output scan, data on the output status file is sent to the output module and the devices are energized or deenergized accordingly.

c) Develop a ladder diagram for 4:1 Multiplexer.

6M

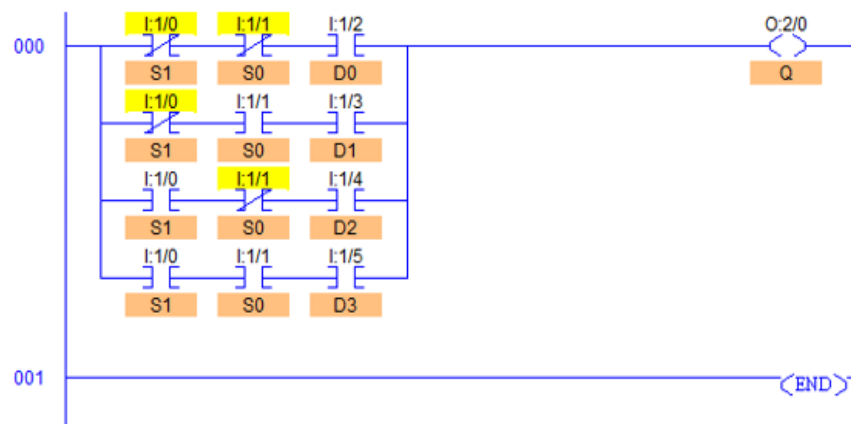
Ans: Truth table of 4:1 Multiplexer is as shown below. Depending on the signal on select lines one of the inputs is selected and directed to the output.

Truth Table: 2M

Ladder Diagram :4M

Select Data Inputs		Output
S_1	S_0	Y
0	0	D_0
0	1	D_1
1	0	D_2
1	1	D_3

Ladder Diagram:





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Q. No.	Sub Q. N.	Answers	Marking Scheme																
6.		Attempt any TWO of the following :	12- Total Marks																
	a)	Illustrate PLC timer in detail.	6M																
	Ans:	<p>Depending on the time delay and operation there are two types of timers PLC timer</p> <p>- (i) ON delay timer</p> <p>(ii) OFF delay timer</p> <p>ON delay timer: This instruction counts time interval when conditions preceding it in the rung are true. Produces an output when accumulated reaches the preset value.</p> <p>Use Ton instruction to turn an output on or off after the timer has been on for a preset time interval. The Ton instruction begins to count time base intervals when the rung conditions become true.</p> <p>The accumulated value is reset when the rung condition go false regardless of whether the timer has timed out</p> <p>Instruction parameter- Timer TON is 3 word element.</p> <table border="1"> <tr> <td></td><td>15</td><td>14 13 12 11 10 9 8 7 6 5 4 3</td><td></td></tr> <tr> <td>word 0</td><td>TT\EN</td><td>TT\EN DN</td><td>16 bit</td></tr> <tr> <td>word 1</td><td>preset value</td><td></td><td>16 bit</td></tr> <tr> <td>word 2</td><td>Accumulator value</td><td></td><td>16 bit</td></tr> </table>		15	14 13 12 11 10 9 8 7 6 5 4 3		word 0	TT\EN	TT\EN DN	16 bit	word 1	preset value		16 bit	word 2	Accumulator value		16 bit	<p>ON delay timer:3 M</p> <p>OFF delay timer:3 M</p>
	15	14 13 12 11 10 9 8 7 6 5 4 3																	
word 0	TT\EN	TT\EN DN	16 bit																
word 1	preset value		16 bit																
word 2	Accumulator value		16 bit																

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Status bit explanation-

- i) **Timer done bit (bit13)-DN** is set when the accumulated value is equal to or greater than the preset value. It is reset when rung condition become false.
- ii) **Timer enable bit (bit 14)-EN** is set when rung condition are true. It is reset when rung condition become false.
- iii) **Timer timing bit (bit15)-TT** is set when rung conditions are true & the accumulated value is less than the preset value. It is reset when the rung conditions go false or when the done bit is set.

(ii) **OFF delay timer** : This instruction counts time interval when conditions preceding it in the rung are false. Produces low output when accumulated value reaches the preset value. Use Toff instruction to turn an output on or off after the timer has been off for a preset timer has been off for a preset time intervals. The Toff instruction begins to count time base intervals when the rung makes a true to false to transition.

As long as rung conditions remain false the timer increments its accumulated value each scan until it reaches the preset value. The accumulated value is reset when the rung conditions go true regardless of whether the timer has timed out. Instruction parameter-Timer TOFF is 3 word element.

		14 13 12 11 10 9 8 7 6 5 4	
	15	3 2 1 0	
word 0	TT\EN	TT\EN DN	16 bit
word 1	preset value		16 bit
word 2	Accumulated value		16 bit

Status bit explanation-

- i) **Timer done bit(bit13)-DN** is reset when the accumulated value is equal to or greater than the preset value.It is set when rung condition are true.
- ii) **Timer enable bit(bit 14)-EN** is set when rung condition are true. It is reset when rung condition become false.
- iii) **Timer timing bit(bit15)-TT** is set when rung conditions are false & the accumulated value is less than the preset value. It is reset when the rung conditions go true or when the done bit is reset.

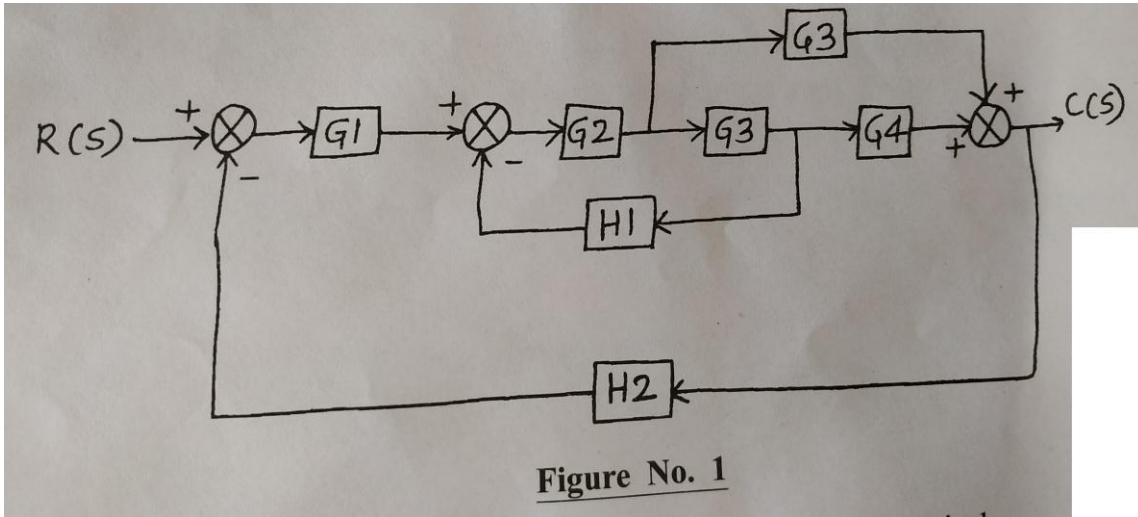
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- b) Apply the block diagram reduction rule to obtain transfer function $C(S)/R(S)$ of the following block diagram. (Refer Figure No. 1)



6M

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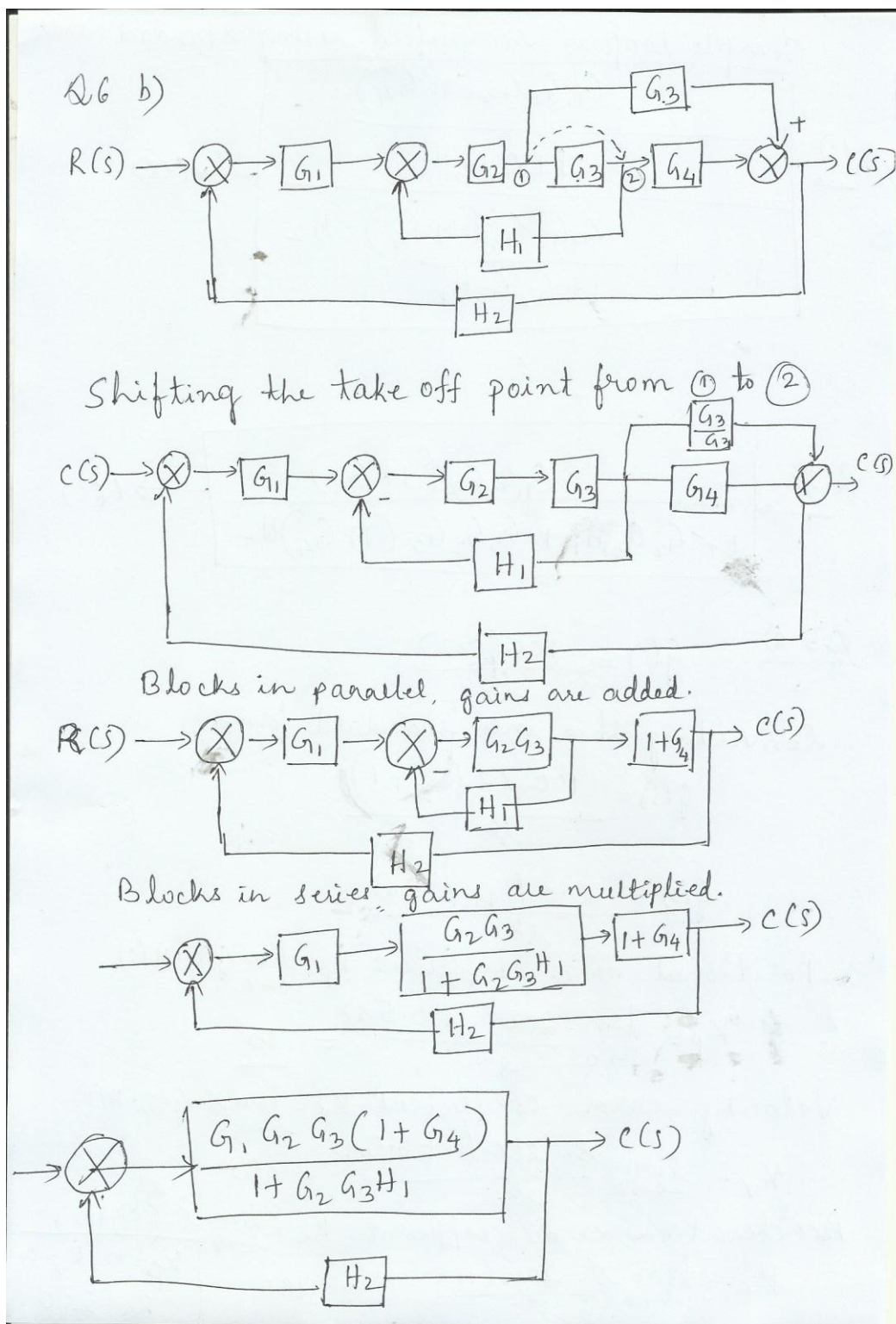
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Ans:

1M for
each
step

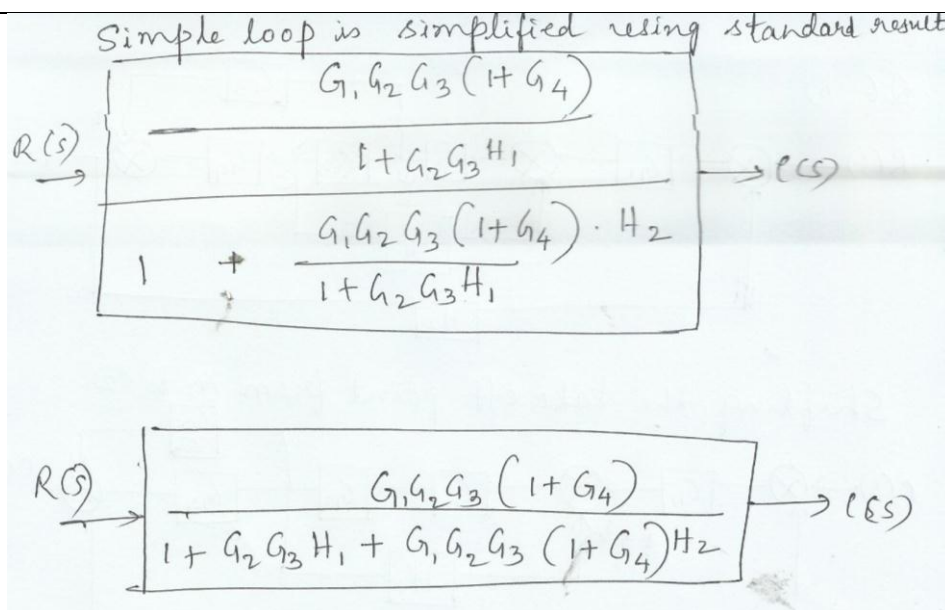


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c)

Describe four standard test inputs with their mathematical expression and graphical representation.

6M

Ans:

Standard test inputs are .

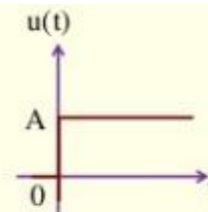
1. Step input
2. Ramp input
3. Parabolic input
4. Impulse input;

Each
test
input
:1.5M

Step-function

- The step signal imitate the sudden change characteristic of actual input signal.

$$u(t) = \begin{cases} A & t \geq 0 \\ 0 & t < 0 \end{cases}$$



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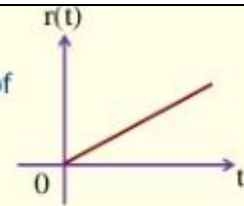
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□ Ramp-function

- The ramp signal imitate the constant velocity characteristic of actual input signal.

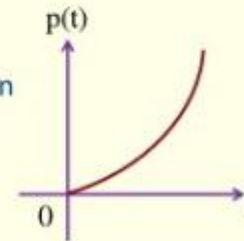
$$r(t) = \begin{cases} At & t \geq 0 \\ 0 & t < 0 \end{cases}$$



□ Parabolic-function

- The parabolic signal imitate the constant acceleration characteristic of actual input signal.

$$p(t) = \begin{cases} \frac{At^2}{2} & t \geq 0 \\ 0 & t < 0 \end{cases}$$



□ Impulse-Function

- The impulse signal imitate the sudden shock characteristic of actual input signal.

$$u(t) = \delta(t) = \begin{cases} A & t = 0 \\ 0 & t \neq 0 \end{cases}$$

