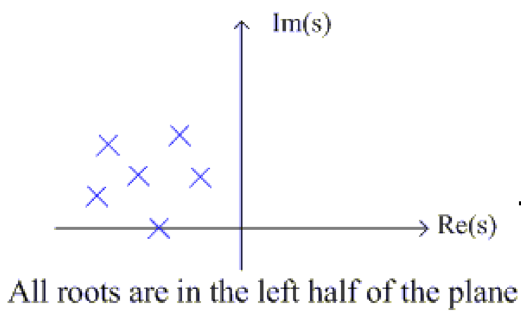
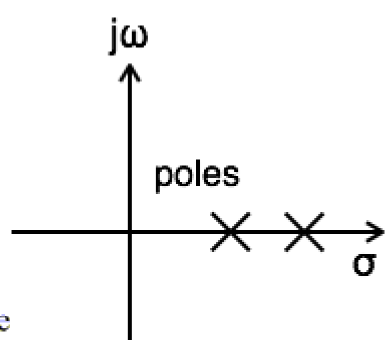
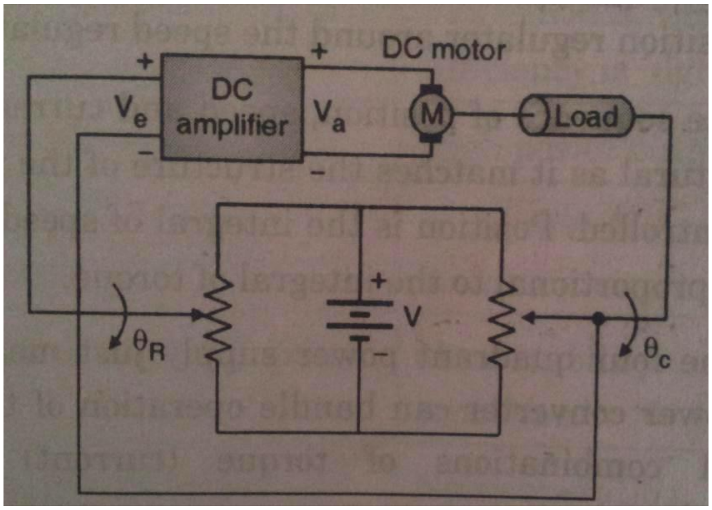
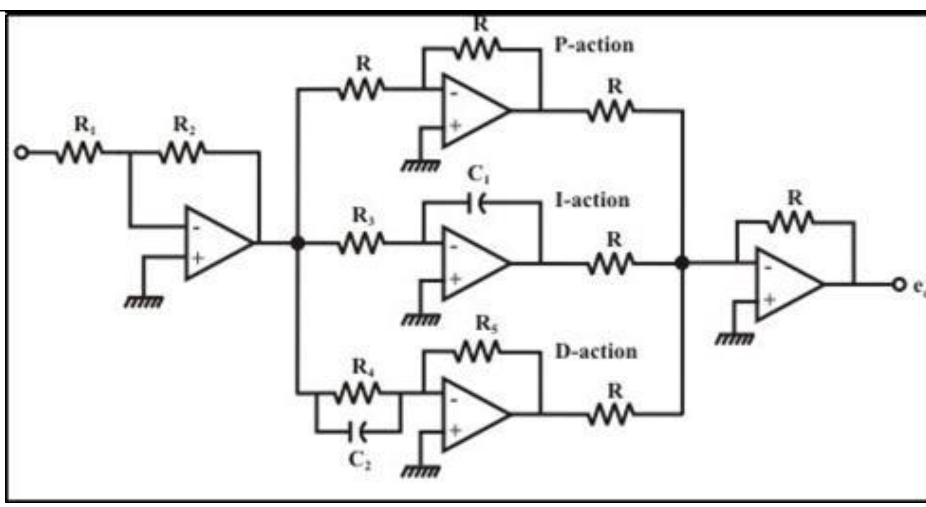
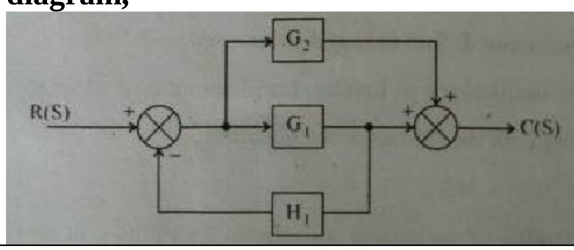
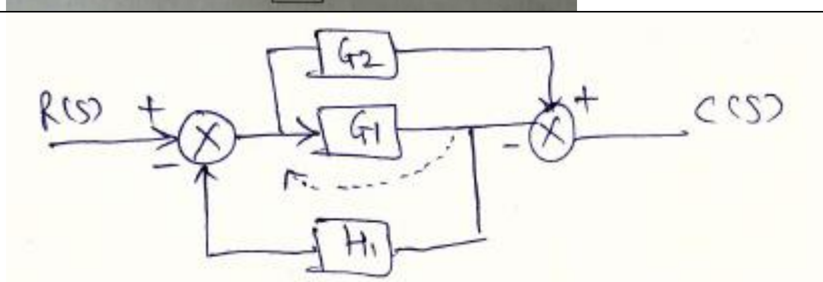
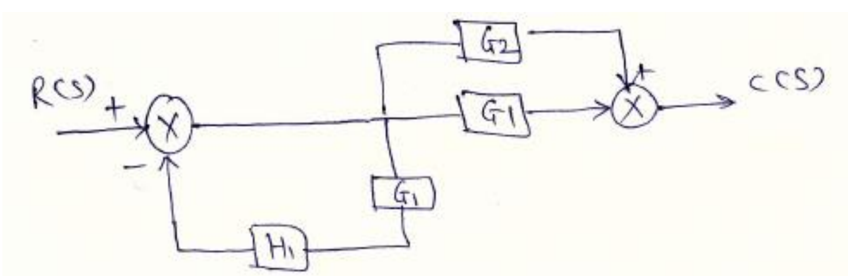
Important Instructions to examiners:

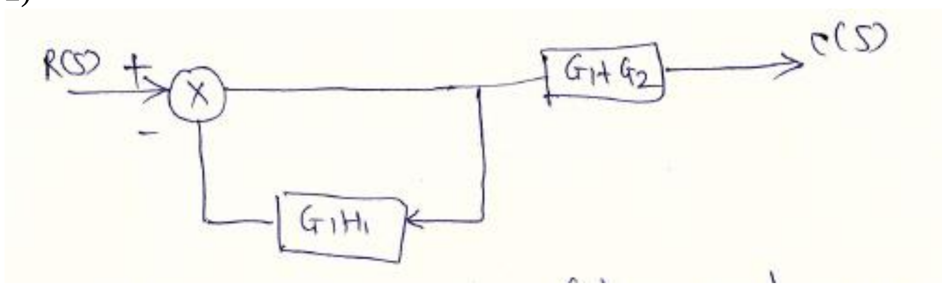
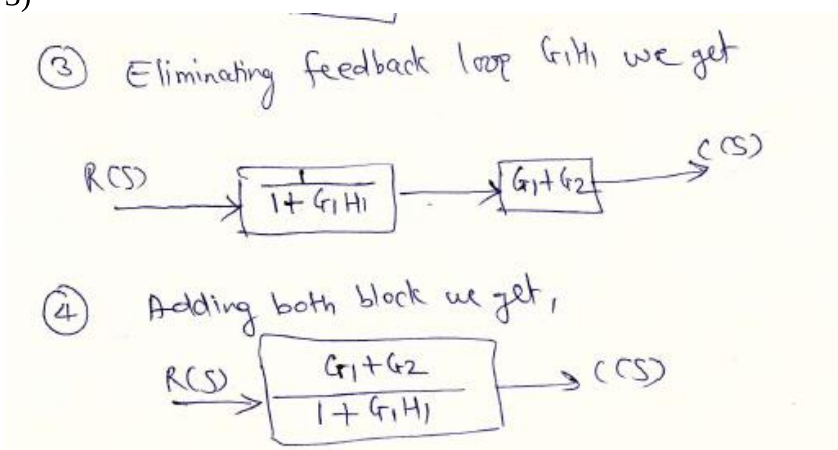
1) The answers should be examined by keywords and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling 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.

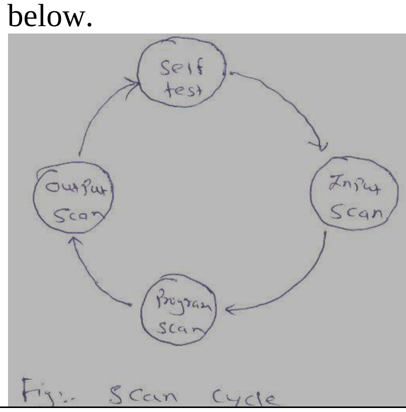
Q. No.	Question & its Answer	Remark	Total Marks
01 A)	**Attempt any THREE of the following**		12
a)	**Define stability. Sketch the root locations in the s-plane for stable and unstable system.**	04	
Ans.	**Stability:** The system is said to be stable if it produces bounded output for a bounded input. It is used to define usefulness of the system. The stability implies that the system performance should not change even if there are small changes in system input. Any control system must be stable.  **Stable System**  **Unstable System** • The system is said to be stable if poles of closed loop the system lies on left half of s-plane • The system is said to be unstable if poles closed loop of the	**02 marks stability** **02 Marks Root Location on s-plane**	

	system lies on right half of s-plane **OR** • **STABILITY** : A linear time invariant system is said to be stable if the system is excited by a bounded input, output is also bounded and controllable. In the absence of the input, output must tend to zero irrespective of the initial condition. • **UNSTABLE**: A linear time invariant system is said to be unstable if for a bonded input it produces unbounded output. In absence of the input, output may not return to zero it shows certain output without input.		
b)	**Give the classification of PLC. Explain modular PLC in brief.**	**04**	
Ans.	**CLASSIFICATION OF PLC** PLC can be classified as follows 1.According to structure of PLC a. Integral type b. Modular Type 2. Depending upon the no. of I/Os a. Small(<100) b. Medium(<10000) c. Large(>10000) 3. Depending upon the I/Os supported a. Digital b. Analog **Modular PLC** • Modular PLC Modular PLC is a constituent part of the PLC, are made of several separate modules, such as CPU module, I / O modules, power modules (including some in the CPU module) and a variety of functional modules. • Modular PLC by the frame or the substrate and the various modules. • Module installed in the socket frame or substrate. • Features The modular PLC is flexible configuration, the system can choose different sizes according to needs, and easy to assemble, easy expansion and maintenance. • Large and medium-sized PLC generally use the modular structure.	**02 Marks Classification** **02 Marks Modular PLC explanation**	
c)	**Define servo system. Draw the block diagram of DC Servo System.**	**04**	
Ans.			

	Definition: Servo system is defined as automatic feedback control system working on error signals giving the output as mechanical position, velocity or acceleration.  **Fig: DC Servo System** 1) The servo system consists of error detector, amplifier, motor as controller, load whose position is to be changed. 2) DC servo system consists of potentiometer as a error detector, DC amplifier, DC motor, DC gear system and the DC load whose position is to be changed. **(NOTE:Explanation is optional)**	**01 Mark Servo System definition** **03 Marks Diagram**	
d)	**Draw electronic PID controller. State its equation.**	**04**	
Ans.	 	**03 Marks Diagram**	

	Equation $V = V_S + K_P*E + K_I*\int_0^t E*dt + K_D*\frac{dE}{dt}$ Where: V = Control variable V_S = Output Set point K_P = Proportional gain E = Error (SP-PV) K_I = Integral gain K_D = Derivative gain t = Time	**01 Mark Equation**	
01 B)	**Attempt any ONE of the following**		**06**
a)	**Using block diagram reduction technique, obtain T.F. from block diagram,**  	**06**	
Ans.	 1)Shifting take-off point of H1 before G1, we get,  	**02 Marks**	

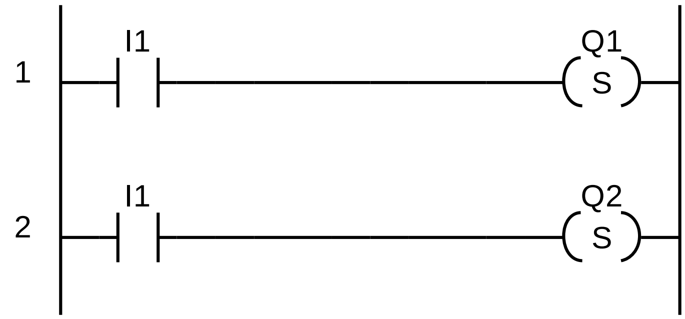
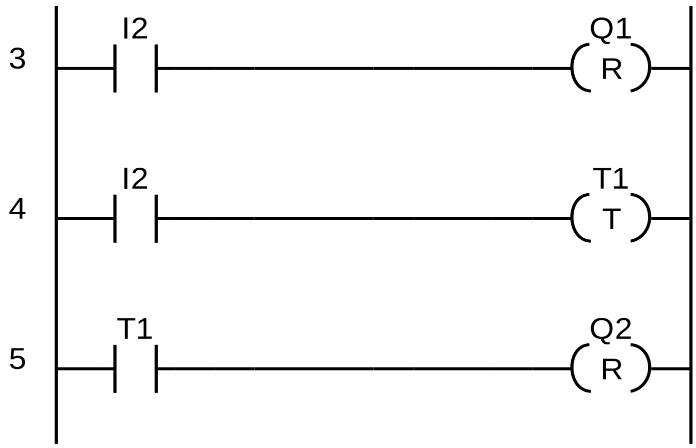
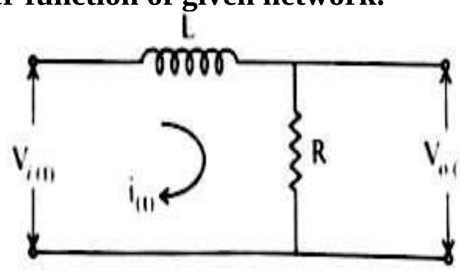
<table>
<tr><td></td><td>2)

</td><td>**01 Mark**</td><td></td></tr>
<tr><td></td><td>3)

</td><td>**01 Mark**

02 Marks</td><td></td></tr>
<tr><td>**b)**</td><td>**Define with respect to PLC**
i) scanning cycle
ii) speed of execution.</td><td>**06**</td><td></td></tr>
<tr><td>**Ans.**</td><td>**Scanning Cycle**
• It is number of states/steps which the controller follows when it is put in RUN mode.
• It is also called as operating cycle and is defined as “the number of states through which the controller scan the program before execution”
• The loaded program is kept in memory of PLC and every time the program will be scan by the PLC. It has four states which are shown in fig. below.

</td><td>**04 Marks**</td><td></td></tr>
</table>

	• The significance of scan cycle in PLC is to test the program and make it error free by going through above four states i.e. self test, input scan, program scan and output scan. **Speed of execution:** The speed at which PLC scans memory and executes the program is referred as a speed of execution. Higher CPU speeds provide faster performance that shortens task time.	**02 Marks**	
02	**Attempt any TWO of the following**		**16**
a)	**Find Kp, Kv, Ka & steady state error for a system with open loop transfer function as** $G(s)H(s) = \dfrac{10(s+2)(s+3)}{s(s+1)(s+4)(s+5)}$ **Where r(t) = 3 + t +** $\frac{t2}{2}$	**08**	
Ans.	i)Positional error coefficient (K_p) is given by, $K_p = \lim_{s\to 0} G(s).H(s)$ Assuming unity feedback system i.e. H(s) = 1, we will get $K_p = \lim_{s\to 0} \frac{10\,(s+2)(s+3)}{s(s+1)(s+4)(s+5)}$ $K_p = \infty$ ii)Velocity error coefficient (K_v) is given by, $K_v = \lim_{s\to 0}\ s.G(s).H(s)$ So, $K_v = \lim_{s\to 0} s.\frac{10(s+2)(s+3)}{s(s+1)(s+4)(s+5)} = \lim_{s\to 0} \frac{10\,(s+2)(s+3)}{(s+1)(s+4)(s+5)}$ $K_v = \frac{60}{20} = 3$ iii)Acceleration error coefficient (K_a) is given by, $K_a = \lim_{s\to 0} S^2.G(s).H(s)$ Assuming unity feedback system i.e. H(s) = 1, we will get	**Kp- 02 Marks** **Kv- 02 Marks**	

	$K_a = \lim_{s\to 0} S^2 . \frac{10(s+2)(s+3)}{s(s+1)(s+4)(s+5)} = \lim_{s\to 0} S^1 . \frac{10(s+2)(s+3)}{(s+1)(s+4)(s+5)}$ i.e. $K_a = 0$ iv) Steady State Error is given as, $e_{ss} = \lim_{s\to 0} \frac{s . R(s)}{1+G(s).H(s)}$ Here $R(s) = L(3+ t + \frac{t^2}{2}) = \frac{3}{s} + \frac{1}{s^2} + \frac{1}{s^3}$ for unit step input, we get $= \lim_{s\to 0} \frac{s(\frac{3}{s}+\frac{1}{s^2}+\frac{1}{s^3})}{1+\frac{10(s+2)(s+3)}{s(s+1)(s+4)(s+5)}} =$ $\lim_{s\to 0} \frac{(3s^2+s+1)(s+1)(s+4)(s+5)/s}{s(s+1)(s+4)(s+5)+10(s^2+5s+6)}$ $e_{ss} = \infty$	**Ka- 02 Marks** **e_{ss} -02 Marks**	
b)	**A unity feedback system is given** $G(s) = \frac{16}{s(s+5)}$ **If a step input is given** **1) Rise Time 2) Peak Time 3) Maximum overshoot 4) Settling Time**	**08**	
Ans.	Comparing above equation with standard equation, $\frac{C(s)}{R(s)} = \frac{Wn^2}{s^2 + 2.\xi.Wn.s + Wn^2}$ We get, $Wn^2 = 16$, So, $W_n = 4$ rad /s $2.\xi.Wn = 5$ So, $\xi = 0.625$ $W_d = W_n\sqrt{1-\xi^2}$ So, $W_d = 3.12$ rad /s	**W_n-01 Mark** **ξ -01 Mark** **W_d- 01 Mark**	

	Ideally the above 4 listed parameters can be given as, i) Rise time is given by tr $=\frac{\pi-\beta}{Wd}$, where $\beta = \frac{\sqrt{1-\xi^2}}{\xi}$ $\beta = \frac{\sqrt{1-\xi^2}}{\xi} = \frac{0.78}{0.625} = 1.24$ tr $=\frac{\pi-\beta}{Wd} = \frac{3.14-1.24}{3.12} = \frac{1.9}{3.12} = 0.608$ sec ii) Peak Time is given by $t_p = \frac{\pi}{Wd} = \frac{3.14}{3.12} = 1\ sec$ iii) Max overshoot is given by $Mp\% = 100 \times e^{-\frac{\pi\xi}{\sqrt{1-\zeta^2}}}$ $Mp = 100 \times e^{-\frac{\pi.\xi}{\sqrt{1-\xi^2}}} = 100 \times e^{-\frac{3.14 \times 0.625}{\sqrt{1-0.39}}}$ $Mp = 100 \times e^{-\frac{1.962}{0.781}} = 100 \times e^{-2.51}$ $Mp = 8.12\ \%$ iv) Settling time is given by ts $= \frac{4}{\zeta.Wn} = \frac{4}{0.625x4} = 1.6$ sec	**β -01 Mark** **Tr-01 Mark** **Tp- 01 Mark** **%Mp-01 Mark** **Ts- 01 Mark**	
c)	**Draw ladder diagram for ON-OFF of lamps for following conditions:** **i) START Push button switch ON green and red lamp &** **ii) STOP push button switch OFF green lamp first and after 20 seconds red lamp**	**08**	
Ans.	I1 & I2 are start & stop push buttons. Q1 & Q2 are Green & Red Lamps T1 is On Delay Timer which turns on after 20 seconds after getting I2 pulse i) start operation	**04 mark**	

	 ii) Stop Operation  **Note: Any relevant ladder logic may considered.**	**04 Mark**	
03	**Attempt any FOUR of the following**		**16**
a)	**Derive the transfer function of given network.** 	**04**	

<table>
<tr><td>Ans.</td><td>Applying KVL to input and output loop we get,
$$V_i(t) = L\frac{di(t)}{dt} + R \cdot i(t) \quad ...(1)$$
$$V_o(t) = R \cdot i(t) \quad ...(2)$$
Taking Laplace transform of Equations (1) and (2)
$$V_i(s) = sL \cdot I(s) + R \cdot I(s)$$
$$V_i(s) = [sL + R]\, I \cdot (s) \quad ...(3)$$
$$V_o(s) = R \cdot I(s)$$
$$\therefore \quad I(s) = \frac{V_o(s)}{R} \quad ...(4)$$
Substituting value of I (s) in Equation (3) we get,
$$V_i(s) = [sL + R]\frac{V_o(s)}{R}$$
$$\therefore \quad V_i(s) = \left[\frac{sL}{R} + 1\right] V_o(s)$$
$$\therefore \quad \frac{V_o(s)}{V_i(s)} = G(s) = \frac{1}{\left[1 + \frac{sL}{R}\right]}$$
Transfer function of given circuit is,
$$\boxed{G(s)\ \frac{V_o(s)}{V_i(s)} = \frac{R}{R + sL}}$$</td><td>02 marks

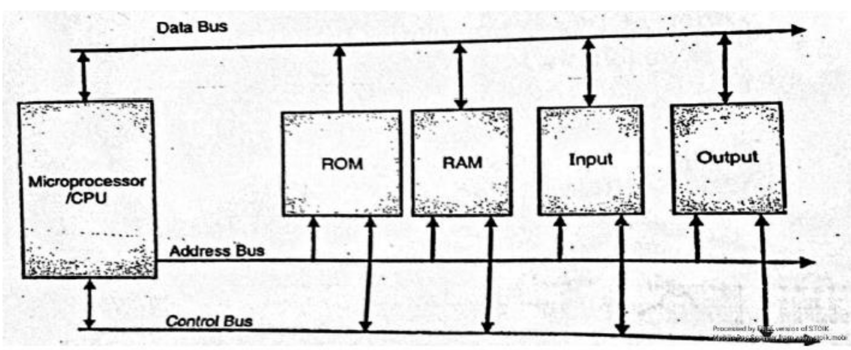
01 mark

01 mark</td><td></td></tr>
<tr><td>b)</td><td>List any four input and four output devices used with PLC.</td><td>04</td><td></td></tr>
<tr><td>Ans.</td><td>Input device:
1. Push button.
2. Temperature switches.
3. Limit switches.
4. Pressure switches.
5. Level Switches.
6. Proximity Switches.

Output devices:
1. Motor.
2. Display.
3. Heater coil.
4. Relay.</td><td>02 marks for input devices(Any four)

02 marks for output devices(Any</td><td></td></tr>
</table>

	5. Lamp. 6. Buzzer. **(Note: any other relevant I/O device can be considered.)**	**four)**	
c)	**Explain the significance of the Laplace transform in control system.**	**04**	
Ans.	**Significance of Laplace Transform-** • Laplace transform convert higher order integral differential equation into simple algebraic form. • Laplace transform converts the differential equation into an algebraic equation in s, which may be real or complex. • Analysis of each component in the system is possible. • It is possible to manipulate the algebraic equation by simple algebraic rules to obtain the solution. • Initial conditions are automatically incorporated. • Both complementary and particular solution can be obtained in one operation, thus gives complete solution. • Allows the use of graphical techniques, for predicting the system performance without actual solving of system differential equations. • Laplace transform convert time domain to frequency domain (s-plane).	**04 marks for significance (Any four points)**	
d)	**For a system with the characteristics equation** $\mathbf{S^4 + 6S^3 + 21S^2 + 36S + 20 = 0,}$ **Find the stability of the system with Rouths Stability criterion.**	**04**	
Ans.		**03 marks for Routh array**	

	$F(s) = s^4 + 6s^3 + 21s^2 + 36s + 20 = 0$ i.e. $a_0 = 1,\quad a_1 = 6,\quad a_2 = 21,\quad a_3 = 36,\quad a_4 = 20$ The Routh's array is as follows, $\begin{array}{c\|lll} s^4 & 1 & 21 & 20 \\ s^3 & 6 & 36 & 0 \\ s^2 & \frac{(6\times21)-(1\times36)}{6} = 15 & 20 & \\ s^1 & \frac{(15\times36)-(6\times20)}{15} = 28 & 0 & \\ s^0 & \frac{(28\times20)-0}{28} = 20 & 0 & \end{array}$ As all the elements in 1st column of Routh array are positive and there is no any sign change in first column of Routh array, hence the system is Stable.	**01 mark for conclusion**	
e)	**Describe in brief memory organization of PLC.**	**04**	
Ans.	 Different types of memory that are generally used in PLC s are as follows: 1. RAM: 2. ROM A.)EPROM B.)EEPROM In PLC program instructions are stored in the memory. An internal communication high way also known as a bus system, carries information to and fro from the CPU, Memory and I/O units under the control of CPU Memory unit for storage of program. The user ladder logic program, is in the memory of PLC. The main program and other programs are necessary for operation of	**02 marks for diagram** **02 marks for description**	

<table>
<tr><td></td><td>PLC.
The organization of the data and information in the memory is called memory map
There are two types of memory used in PLC: Volatile and nonvolatile memory, in nonvolatile memories are generally used for storing user program so that the programs can return during power failure.

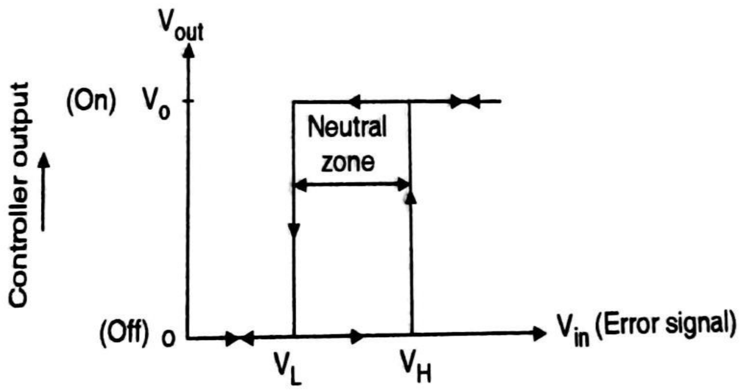
OR

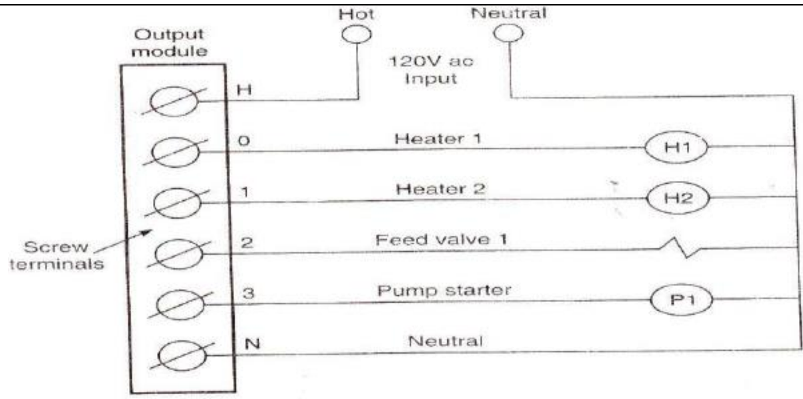
Memory is classified into two types:
1. Storage memory: in storage memory store information on the status of i/o devices, pre assigned value of internal relay status and values for mathematical functions, this is called a data table or register table and stores information in two types: status and numbers,.
Status is stored in the form of ON or OFF and nos are stored in the form of 1"s and 0"s is unique bit of memory.
2. User memory: in this memory, ladder logic programming is carried out and stored.
User memory consists of program files or register table and holds the complete operation.</td><td></td><td></td></tr>
<tr><td>04 A)</td><td>Attempt any THREE of the following</td><td></td><td>12</td></tr>
<tr><td>a)</td><td>State the principle of ON-OFF control action. Write its standard equation & define neutral zone.</td><td>04</td><td></td></tr>
<tr><td>Ans.</td><td>• This is one of the most common & simplest mode of controller.
• It has to control two positions of control element, either on or off hence this mode is called as ON OFF controller, it is the cheapest controller & often used if its limitations are well within the tolerance.
• This controller mode has two possible output states namely 0 % & 100%.
• Mathematically this can be expressed as

$P(t) = 0\% \text{ (OFF)} \quad \text{for } e_p < 0$
$\qquad\quad 100\% \text{ (ON)} \quad \text{for } e_p > 0$

Where p (t) – Controlled output
ep - Error based on % of span
• Hence if the error rises above a certain critical value, the output changes from 0% to 100%. If the error decreases below certain critical value, the output falls from 100% to 0%.</td><td>02 marks for principle

01 mark for equation</td><td></td></tr>
</table>

<table>
<tr><td></td><td>Neutral Zone-

In practical implementation of the two-position controller, there is an overlap as e(t) increases through zero or decreases through zero. In this span, no change in the controller output occurs.
Until an increasing error changes by Δe(t) above zero, the controller output will not change state. In decreasing, it must fall Δe(t) below zero before the controller changes to 0%.
The range 2Δe(t) is referred to as neutral zone or differential gap.
Two-position controllers are purposely designed with neutral zone to prevent excessive cycling.
The existence of such a neutral zone is an example of desirable hysteresis in a system.</td><td>01 mark for neutral zone definition</td><td></td></tr>
<tr><td>b)</td><td>Draw typical wiring details & four specifications of AC output module of PLC.</td><td>04</td><td></td></tr>
<tr><td>Ans.</td><td>The below figure show the basic field wiring for digital 120V AC output module. The Wiring diagrams show how wires of output devices are connected to screw terminals of PLC modules. As per the wiring diagram, User has to connect the wires of input and output devices to PLC or Module.
It can be thought of as a simple switch power can be provided to control the output device. During normal operation, processor sends the output state that was determined by logic diagram of output module. The module then switches the power to the field devices. A fuse is normally provided in that the output circuit of the module to prevent excessive current from damaging the wiring to the field devices.</td><td>02 marks for wiring details</td><td></td></tr>
</table>



Typical discrete output module wiring diagram

Specifications-

02 marks for specification (Any four)

Item	24V DC Output
Rated Voltage	24V DC
Voltage Range	20.4 to 28.8 V DC
Max. Surge Current	8 A for 100 ms
Rated current per point	0.75 A
Rated current per common	6 A
On state contact resistance	0.3 Ω maximum

c) Explain the need of PLC in automation. **04**

Ans. **Need of PLC in automation** — **04 marks(Any four points)**

- To reduce human efforts.
- To get maximum efficiency from machine and control them with human logic
- To reduce complex circuitry of entire system
- To eliminate the high costs associated with inflexible, relay-controlled systems.
- Replacing Human Operators (Dangerous Environments & Beyond Human Capabilities)

Benefits of PLC in automation

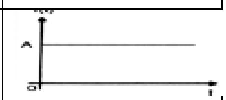
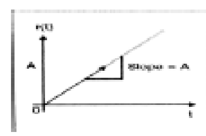
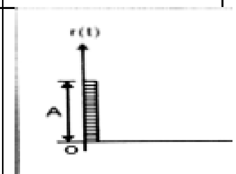
- Higher productivity.
- Superior quality of end product.
- Efficient usage of energy and raw materials
- Improved safety in working conditions.
- Fast and Easily programmed and have an easily understood programming language.

d) What are different standard test inputs? Draw them & give their Laplace representation. **04**

Ans. **Standard test input signals-** — **01 mark for representation**

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

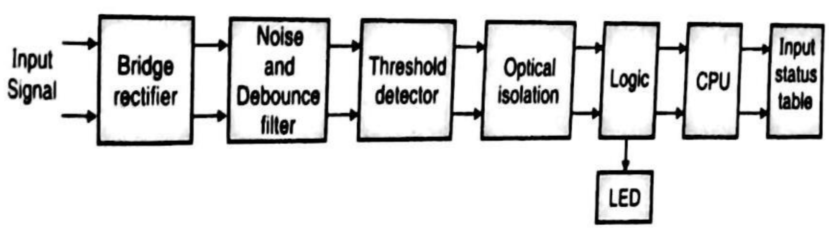
(any four Laplace transform each)

Standard test input	**Laplace Representation**	**Waveforms**
Step input(position function) r(t)	L.T of r(t) =R(s)=A/s	
Rampinput(Velocity function) r(t)	L.T of r(t) = R(s)=A/s^2	
Parabolic input(Acceleration r(t) function)	L.T of r(t) = R(s)=A/s^3	
Impulse input r(t)	L.T of r(t) = R(s)= 1 if A=1	

04 B) **Attempt any ONE of the following** **06**

a) **Draw the block diagram of discrete input module & explain each block.** **06**

Ans.

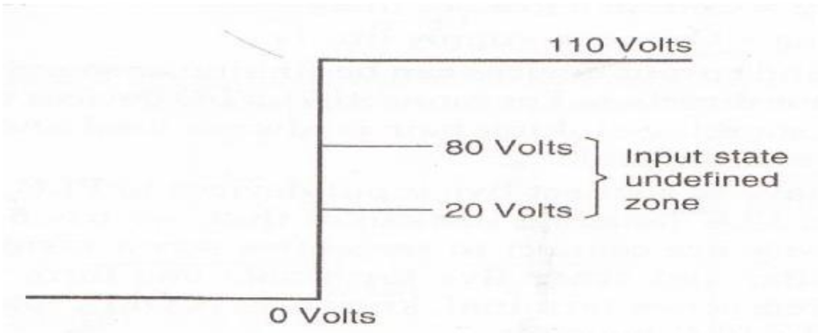
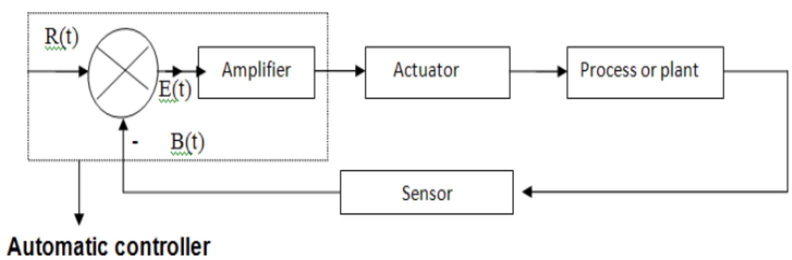


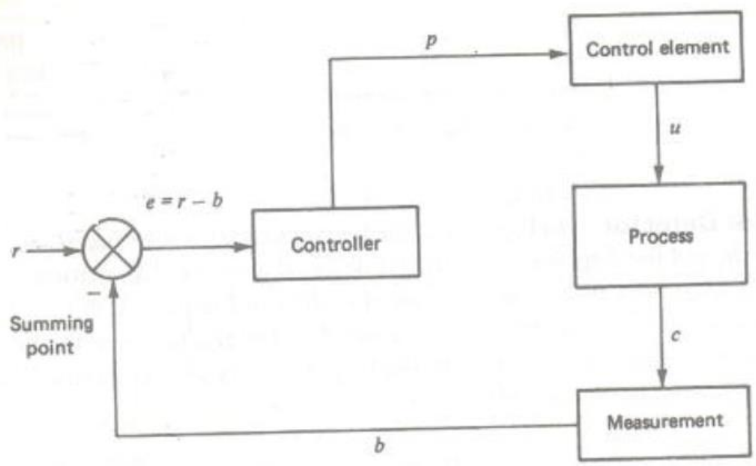
03 marks for diagram

Power conversion:
It consists of rectifier which converts the incoming AC signal to a pulsating dc level, which is passed through filter and other logic in order to deliver a clean and denounced dc signal.

03 marks for explanation

Threshold detector:

	It detects if monitoring signal has reached or exceeded a predetermined value. A valid ON sate will be between 80- 132V ac. The upper voltage limit for a valid OFF state is below 20V. The voltage between 20V and 80V is called undefined zone.  **Isolation:** It is made up of an optical isolator which separate high voltage from CPU‟s low voltage control logic. **Logic section:** It passes the input signal to the module's input address LED and the CPU.		
b)	**Draw the labeled block diagram of process control system and explain each block.**	**06**	
Ans.	 **Explanation** - Process control system consists of process or plant, sensor, error detector, automatic Controller, actuator or control element. 1) Process or plant- process means some manufacturing sequence. It has one variable or multivariable output. Plant or process is an important element of process control system in which variable of process is to be controlled. 2) Sensor measuring elements – It is the device that converts the output variable into another suitable variable which can acceptable by error detector Sensor is present in f/b path of close loop system. 3) Error detector – Error detector is he subtracting summing points whose output is an error signal i.e. e(t)=r(t) b(t) to controller for comparison & for the corrective action. Error detector compares between actual signal & reference i/p i.e. set point.	**03 marks for diagram** **03 marks for explanation**	

	4) Automatic controller- Controller detects the actuating error signal, which is usually at a very low power level, and amplifies it to a sufficiently high level .i.e. means automatic controller comprises an error detector and amplifier. 5) Actuator or control element – Actuator is nothing but pneumatic motor or valve, a hydraulic motor or an electric motor, which produces an input to the plant according to the control signal getting from controller. **OR**  **Explanation :** The block diagram of process control system consists of the following blocks:- 1) Measuring element: It measures or senses the actual value of controlled variable "c" and converts it into proportional feedback variable b. 2) Error detector: It receives two inputs: set point "r" and controlled variable "p". The output of the error detector is given by e= r-b. "e" is applied to the controller. 3) Controller: It generates the correct signal which is then applied to the final control element. Controller output is denoted by "p". 4) Final control element: It accepts the input from the controller which is then transformed into some proportional action performed by the process. Output of control element is denoted by "u". 5) Process: Output of control element is given to the process which changes the process variable. Output of this block is denoted by "u".		
05	**Attempt any TWO of the following**		**16**
a)	**List & explain the timer instruction of PLC. Draw the ladder diagram to verify** **(i) OR gate&** **(ii) NOR gate logic**	**08**	
Ans.	Depending on the time delay and operation, there are two types of timers	**04 marks for brief**	

- **PLC timer**- (i) ON delay timer
  (ii) OFF delay timer

Explanation

Description (i) ON delay timer

1) This instruction counts time interval when conditions preceding it in the rung are true. Produces an output when accumulated reaches the preset value.

2) Use T_{on} instruction to turn an output on or off after the timer has been on for a preset time interval. The T_{on} instruction begins to count time base intervals when the rung conditions become true.

3) The accumulated value is reset when the rung condition go false regardless of whether

the timer has timed out.

Instruction parameter- Timer T_{ON} is 3 word elements.

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

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.

Description (ii) OFF delay timer

1)This instruction counts time interval when conditions preceding it in the rung are produces low output when accumulated value reaches the preset value.

2) Use T_{off} 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.

3) As long as rung conditions remains 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 T_{OFF} is 3 word elements.

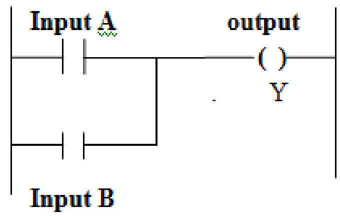
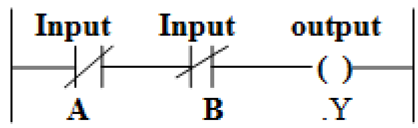
	15	14 13 12 11 10 9 8 7 6 5 4 3 2 1 0	
word 0	TT\EN	TT\EN DN	16 bit
word 1	preset value		16 bit
word 2	Accumulator value		16 bit

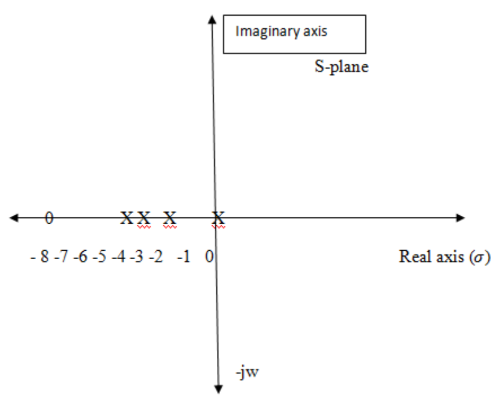
Status bit explanation-1

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.

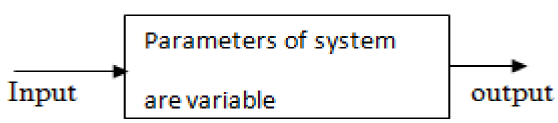
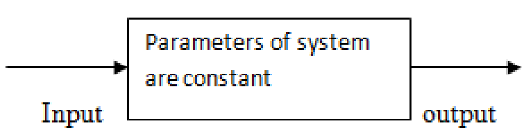
a) OR gate ladder diagram

$$y = A + B$$

	 b)NOR gate ladder diagram $. y = \overline{A+B} = \bar{A}.\bar{B}$  	**04 marks ladder diagram**	
b)	**Define the terms (i) Poles,(ii)Zeros,(iii) Order of system&(iv) Characteristics equation. Also for a given transfer function** $\frac{C(s)}{R(s)} = \frac{10(s+8)}{s(s+4)(s^2+5s+6)}$ **Find(i) Poles,(ii)Zeros,(iii) Plot them on 's'plane**	**08**	
Ans.	I. Poles-It is the value of polynomial which makes the transfer function infinite,after putting the value of 's' in denominator of transfer function. II. Zeros- It is the value of polynomial which makes the transfer function zero,after putting the value of s' innumerator of transfer function. III. Order of system-It is the highest power of 's'in characteristics equation of transfer function. IV. Characteristic eqn-The equation which is obtained by equating the denominator of a transfer function equal to zero, whose roots are the poles of a transfer function is called characteristic equation of that system. $F(s) = b_0 s^n + b_1 s^{n-1} + b_2 s^{n-2} + b_3 s^{n-3} + \cdots .... + b_n = 0.$ $F(s)$ is called characteristics equation. Given transfer function is	**01 mark for each definition**	

	$\frac{C(s)}{R(s)} = \frac{10(s+8)}{s(s+4)(s^2+5s+6)}$ i) Poles of T.F Characteristics equation is $F(s) = s(s+4)(s^2+5s+6)$ Equating $F(s)$ with zero. $s(s+4)(s^2+5s+6) = 0$ $s(s+4)(s+3)(s+2) = 0$ Hence poles are 0,-4,-3,-2 ii) Zeros of T.F Numerator of T.F is $10(s+8) = 0$ Hence zero is -8. iii) Pole-Zero plot  	**01 mark for each pole & zero calculation** **02 marks for pole-zero plot**	
c)	**A unity feedback system has** $G(s)H(s) = \frac{k}{s(s+2)(s+4)(s+8)}$ **Where k is positive. Determine the range of values of k for the system to be stable.**	**08**	
Ans.	(i) characteristics equation of given T.F is given as $F(s) = 1 + G(s)H(s) = 1 + \frac{k}{s(s+2)(s+4)(s+8)}$	**01 mark characteristics equation**	

	Hence $F(s)= s(s+2)(s+4)(s+8)+k$ $F(s)= s(s+2)(s+4)(s+8)+k=0$ $F(s) = s^4+14s^3+56s^2+64s+k=0$ (ii) Range of k for stability From above equation even coefficients are 1,56,k&odd coefficients are 14,64 Routh's array is as follows S^4 | 1 56 k S^3 | 14 64 0 S^2 | 51.42 k 0 S^1 | $\frac{(51.42X64)-14k}{51.42}$ 0 …… S^0 | K For stable system,all the elements of first column of Routh's array should be positive Hence element K > 0 From row S^1 element $\frac{(51.42X64)-14k}{51.42} > 0$ 32.90-14k > 0 32.90>14k K<235.06 Hence to make system to be stable, range of k is 0 < k < 235.06	**05 marks for construction of Routh array** **02 marks for finding range of K**	
06	**Attempt any FOUR of the following**		**16**
a)	**Why 'D' control action is not used alone? Justify**	**04**	
Ans.	Significance of why Derivative mode cannot used alone are (i) It can't not give any output for zero or constant error (ii)It is ineffective for slowly changing error&hence causes the	**04 marks for relevant**	

	drift. (iii) It amplifies the noise signal & causes saturation effect on the system (iv)It does not eliminate the steady state error(offset)	**explanation**	
b)	**Define:** **i Linear & Nonlinear system.** **ii Time varying& Time in-varying system.**	**04**	
Ans.	**(i)Linear & Nonlinear system.** ➢ **Linear system** is defined as a system which satisfies the following properties: 1.Additivity property –$f(x+y) = f(x) + f(y)$ 2Homogenity property-$f(\alpha.x) = \alpha.f(x)$ The above equations constitute a principle of superposition. ➢ **Nonlinear system-** It is the system which does not follow the principle of supeposition. **(ii)Time varying &Time in-varying system** ➢ Time varying system –A time variant system is defined as a control system in which parameters of the system are varying with time that means as time passes parameters varies.  ➢ Time in-varying system-Atime in - variant system is defined as a control system in which parameters of the system does not vary with time. 	**01 mark each definition**	
c)	**List two instructions each of the following:** **i) Relay instruction.** **ii) Data handling instructions.** **iii) Logical instructions** **iv) Comparision instruction**	**04**	

Ans.	**i) Relay instructions** a) Normally open contact(NO contact) -  b)Normally close contact(NC contact) -  c)Set instruction (S): ——(S) —— d)Contact coil or outputcoil-() ——— ——— **ii Data handling instruction** a) MOV instruction (value,destination) - moves a value to memory location. b)PUSH direct c)POP direct **iii) Logical instruction** a) AND-perform logical AND operation between two operands. b) OR- perform logical OR operation between two operands. c) XOR-perform the logical EX-OR operation between two operands. d) NOT- It has single source and perform logical NOT operation and store result in destination memory. e) **iv)Comparison instruction:** a)EQU(value, value)-equal b)NEQ(value, value)-not equal c)LES(value, value)-less than d)LEQ(value, value)-less than or equal	**01 mark each**	
d)	**Draw electronic PD-controller. state its equation. Explain PD controller in brief.**	**04**	
Ans.	1)The combination of proportional plus derivative mode gives PD controller. 2) Diagram of PD controller is given as	**02 marks for diagram**	

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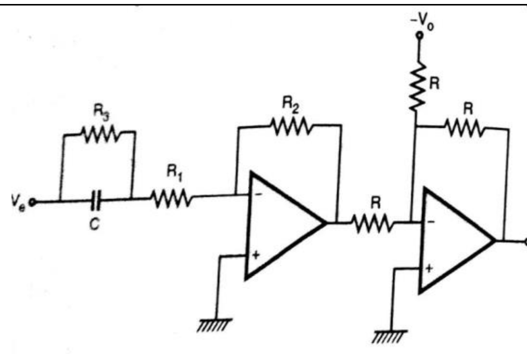
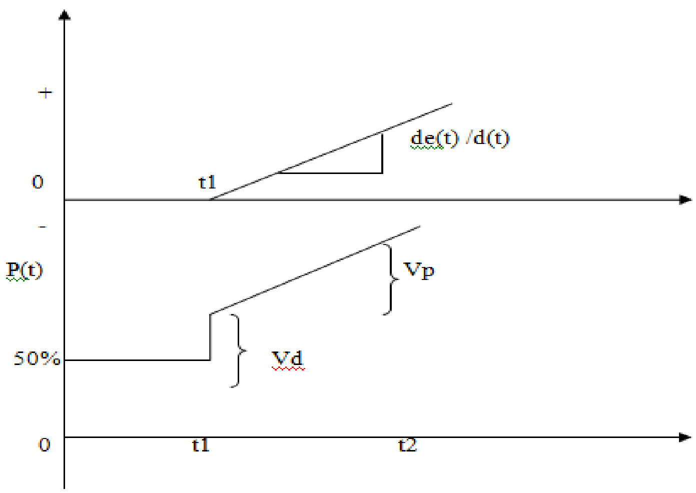
<tr><td></td><td>

3)The mathematical expression of PD mode is given as

$$p(t) = K_p e(t) + K_p K_d \frac{de(t)}{dt} + P(0)$$

4)The behavior of such PD mode to ramp type of input is given as follows



The ramp function of error occurs at t=t1.The derivative mode causes a step Vd at t1 & proportional mode causes a rise of Vp equal to Vd at t2.</td><td>01 mark for equation

01 mark for brief explanation of PD controller with waveform</td><td></td></tr>
<tr><td>e)</td><td>Draw neat sketch of unit step response of a second order system with neat labeling</td><td>04</td><td></td></tr>
<tr><td>Ans.</td><td></td><td></td><td></td></tr>
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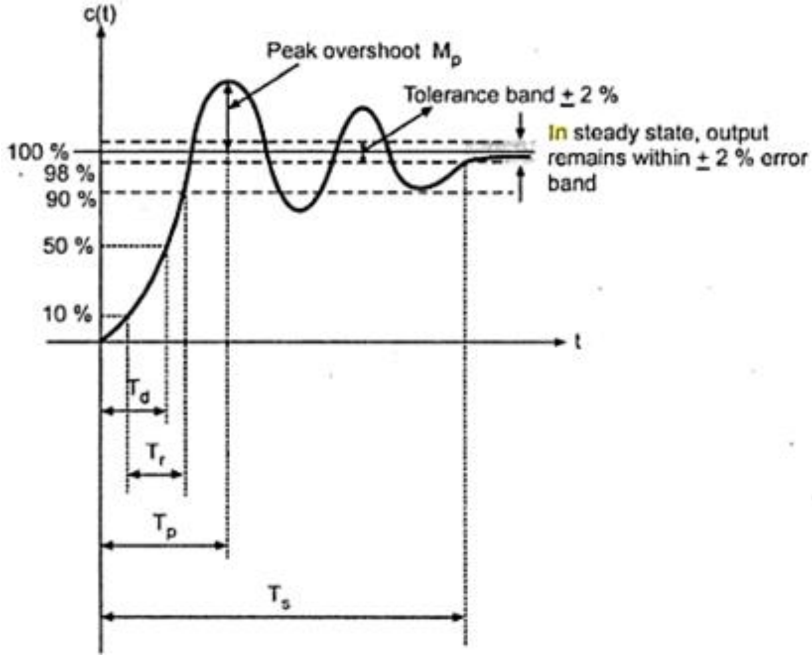

Fig- Unit step response of second order system
Where,
Tp- Peak time(sec)
Ts-Settling time(sec)
Tr-Rise time(sec)
Td-Delay time(sec)
Mp-maximum peak overshoot(%)
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02 marks for diagram

02 marks for labelling
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