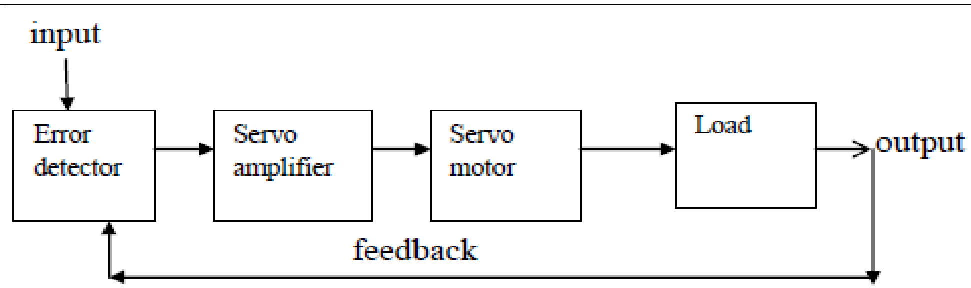
MODEL ANSWER

WINTER– 18 EXAMINATION

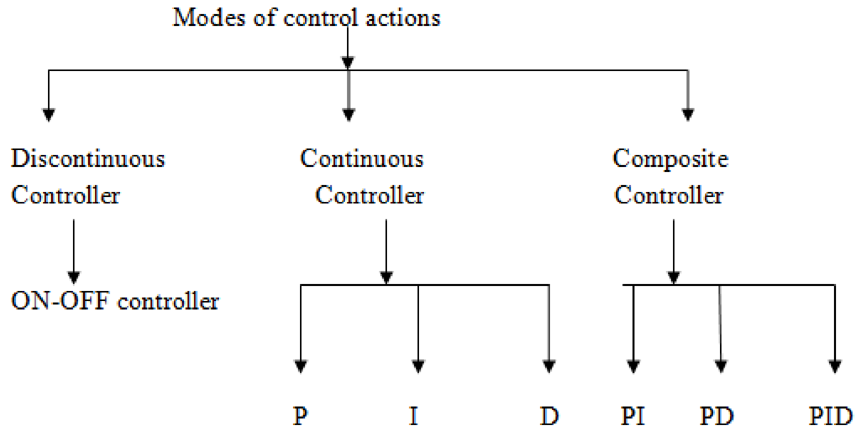
Subject Title: CONTROL SYSTEM & PLC Subject Code: 17536

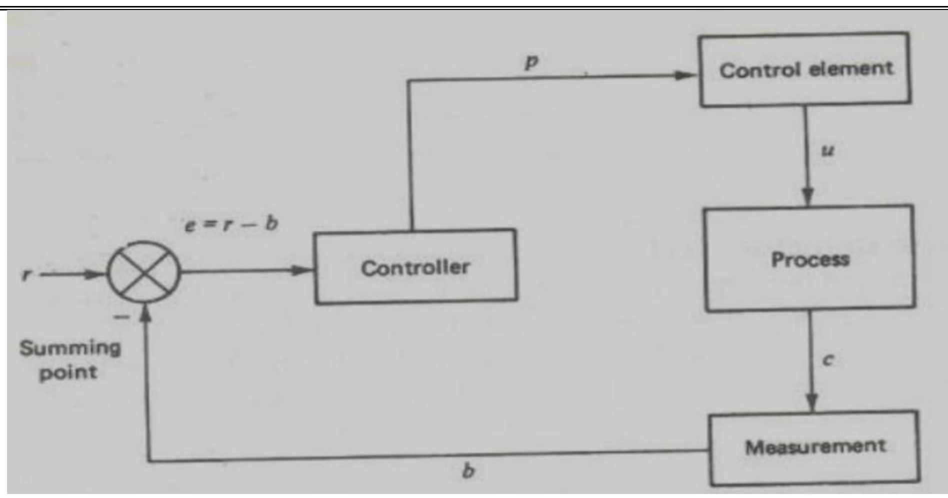
Important Instructions to examiners:

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 judgment 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.

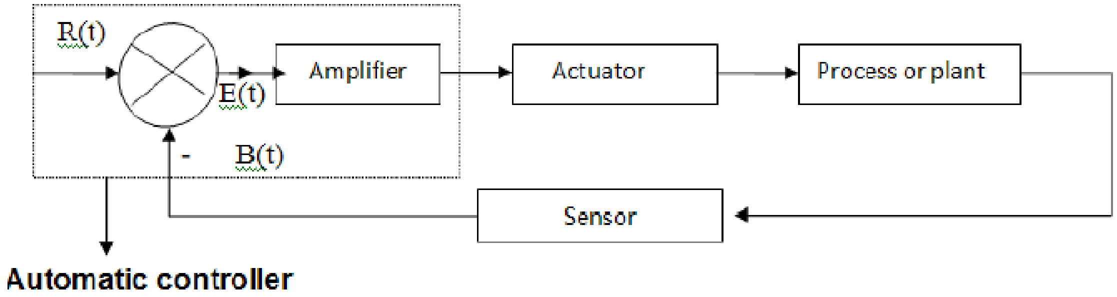
Q. No.	Sub Q.N.	Answer	Marking Scheme
Q.1		**Attempt any THREE :**	**12-Total Marks**
	a)	**Draw the block diagram of DC servo system.**	**4 M**
	Ans:		**4M**
	b)	**Classify the different modes of process control actions.**	**4 M**
	Ans:	Discontinuous control actions: on-off controller Continuous control actions: Proportional, Integral and Derivative Combinational control actions: Proportional Integral (PI), Proportional Derivative (PD) and Proportional Integral and Derivative (PID)	**4M** **½ marks for each modes**

Or



	c)	**Name any four I/P and O/P devices each used with PLC.**	**4 M**
	Ans:	Input devices used with PLC are push button, limit switch, pressure switch, Thermocouple, Level switch, RTD	**2M(any 4)**
		Output devices used with PLC are Motor, display, solenoid, heater, lamps, relays, buzzer, stepper motor, alarm	**2M(any 4)**
	d)	**Draw the block diagram of process control system.**	**4M**
	Ans:		**4M**

OR



B)	**Attempt any ONE :**	**6 M**
a)	**Draw the block diagram of AC output module. Draw its wiring diagram.**	**6M**
Ans:	See block diagram and wiring diagram below.	**3M for block diagram**
		3M for relevant wiring diagram

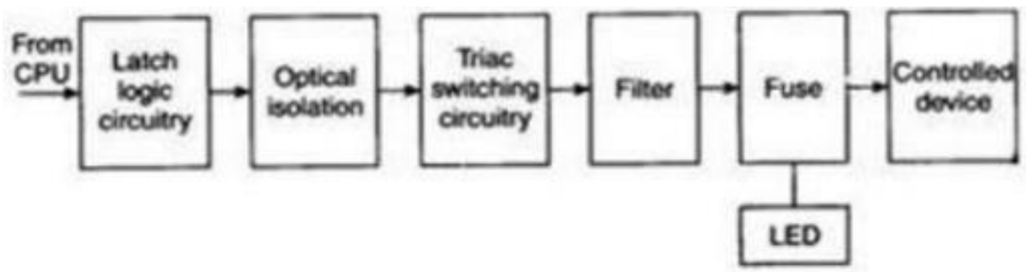
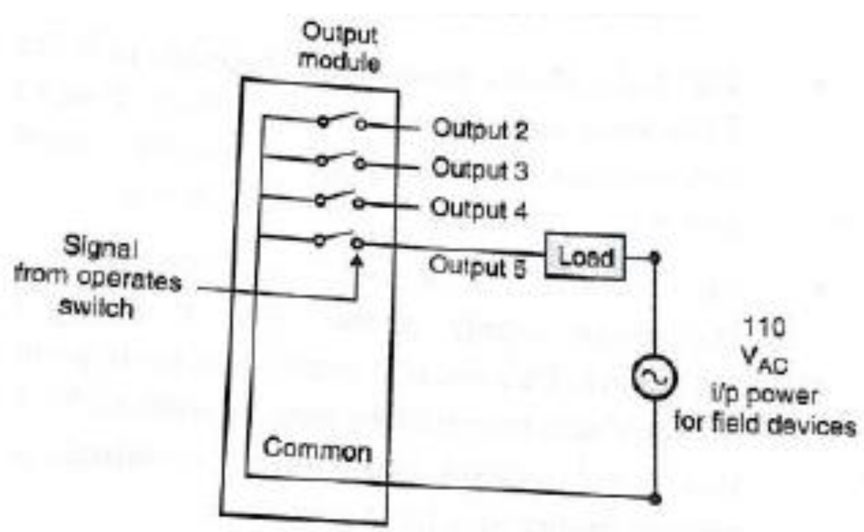
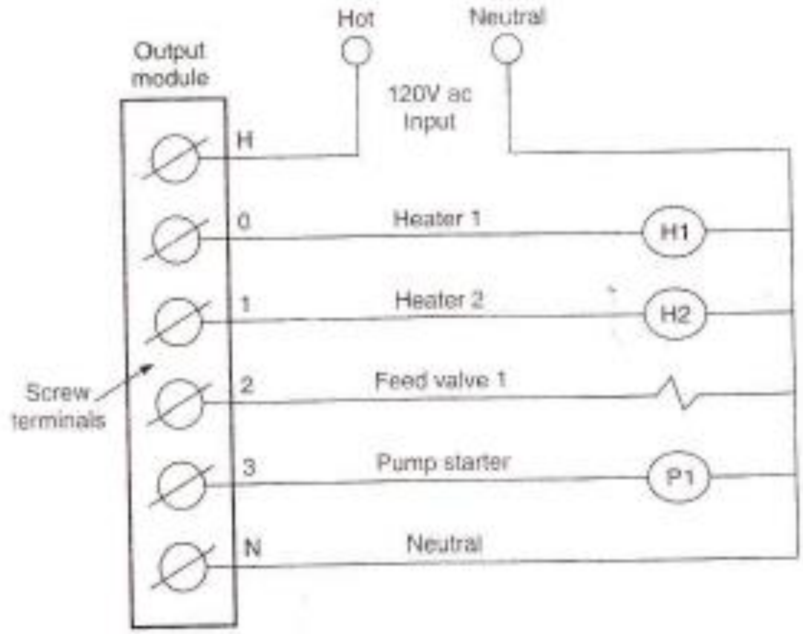
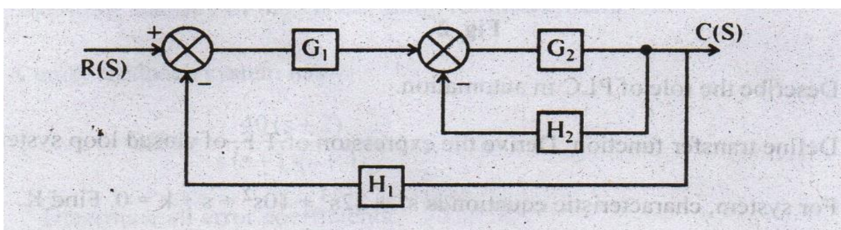
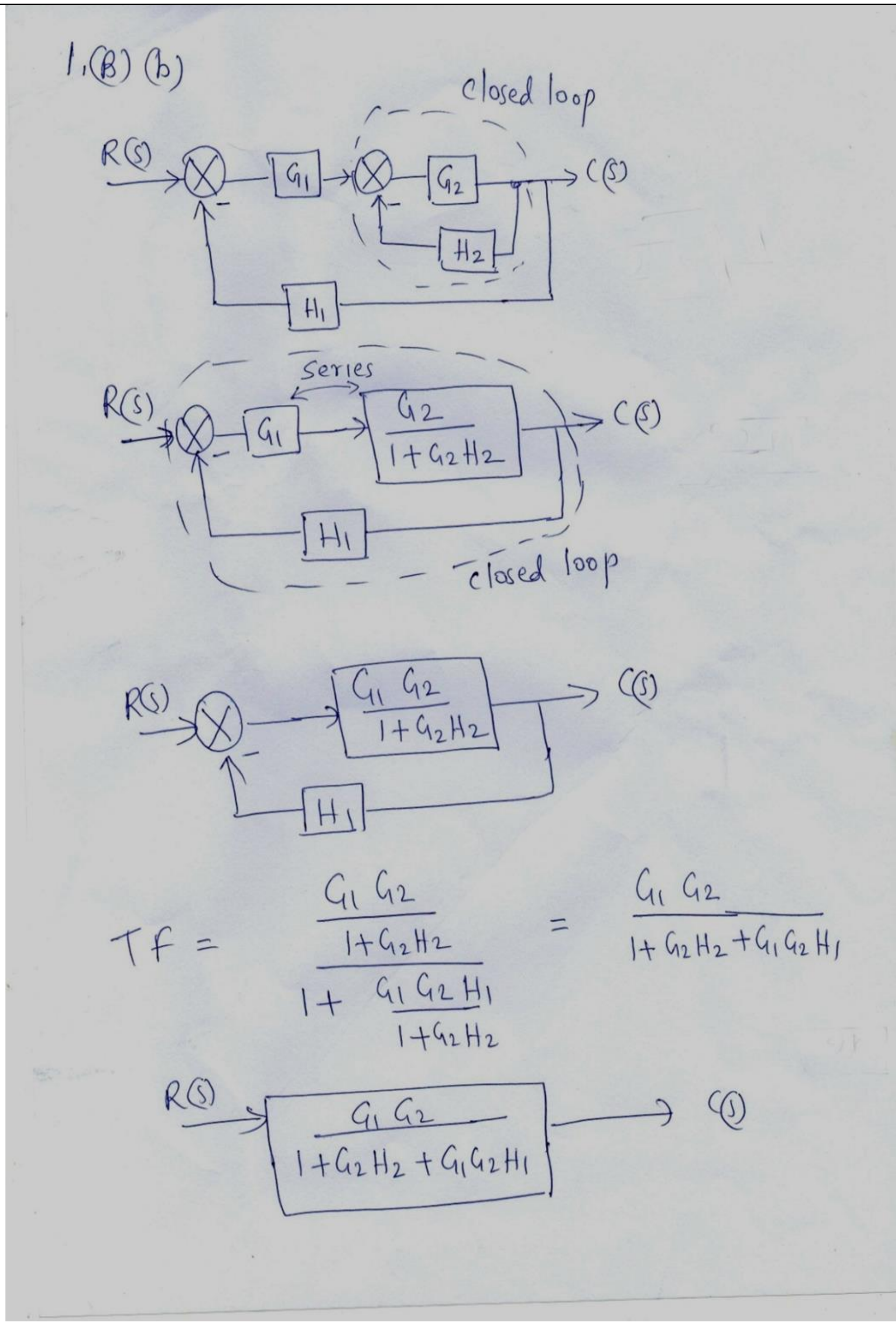


Fig. Block diagram of AC output module



Typical wiring for 120 V AC discrete output module

		 Typical discrete output module wiring diagram	
	b)	**Derive the transfer function of the following block diagram in fig. 1:**  **Fig. 1**	**6 M**

	Ans:		**2 M** **2 M** **2 M**
Q 2		**Attempt any TWO :**	**16 - Total Marks**
	a)	**For a unity feedback system, the TF is given by** $\frac{C(s)}{R(s)} = \frac{25}{S^2 + 6S + 25}$ **Find i) rise time ii) peak time iii) peak overshoot iv) settling time.**	**8 M**

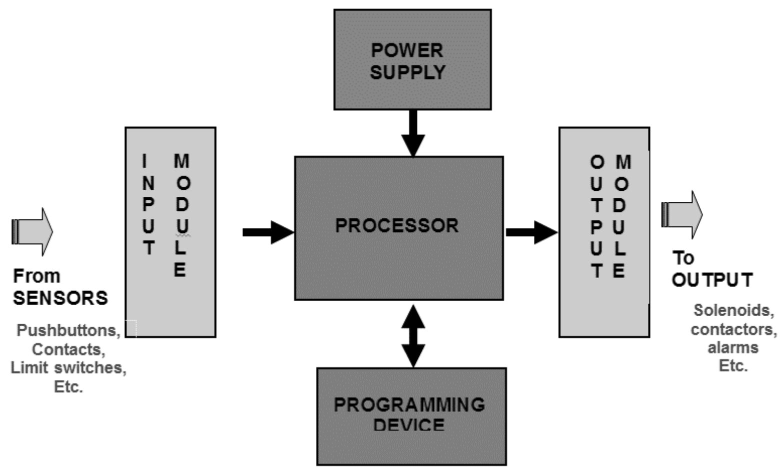
	Ans:	**Comparing with standard equation** $\frac{C(S)}{R(S)} = \frac{G(S)}{1+G(S)H(S)} = \frac{{w_n}^2}{S^2+2\xi\ w_n S+{w_n}^2} = \frac{25}{S^2+6S+25}$ $${w_n}^2 = 25,\ \ w_n = 5$$ $$2\xi\ w_{n=}6,\qquad \xi = 0.6$$ $$w_d = w_n\sqrt{1-}\xi^2 = 4\,rad/sec$$ **1)** **Rise Time**: $T_r = \frac{\pi-\theta}{w_d}$ $$\theta = \tan^{-1}(\frac{\sqrt(1-\xi^2)}{\xi}) = 0.92$$ $$\boldsymbol{T_r} = \frac{\pi-0.92}{4} = \mathbf{0.55}\boldsymbol{sec}$$ **2)** **Peak Time**: $T_p = \frac{\pi}{w_d} = \frac{\pi}{4} = \mathbf{0.785}\ \boldsymbol{sec}$ **3)** **% Peak overshoot:** $\%\ \boldsymbol{M_p} = \boldsymbol{e}^{-\pi\xi/\sqrt(1-\xi2)} \times \mathbf{100}\% = \mathbf{9.47}\%$ **4)** **Settling time:** $T_s = \frac{4}{\xi\ w_n} = \mathbf{1.33}\ \boldsymbol{sec}$	**2M** **1.5M** **1.5M** **1.5M** **1.5M**
	b)	**An unity feedback system has G(S),** $$\mathrm{G(S)} = \frac{\mathbf{10\ (S+1)}}{\mathbf{S^2(S+2)\ (S+10)}}$$ **Find,** **i)** **Type of system** **ii)** **Error coefficient kp, kv & ka** **iii)** **Steady state error for i/p,** **r(t) = 1 + 4t +t²/2**	**8 M**
	Ans:	**i)** **Type of system is 2** **ii)** **Error coefficient** $\boldsymbol{K_P} = \lim_{s\to 0} \boldsymbol{G(S)H(S)} = \infty$ $$\boldsymbol{K_V} = \lim_{s\to 0} \mathbf{S}\,\boldsymbol{G(S)H(S)} = \infty$$ $$\boldsymbol{K_a} = \lim_{s\to 0} \mathbf{S^2}\,\boldsymbol{G(S)H(S)} = \frac{\mathbf{10}}{\mathbf{2\times 10}} = \mathbf{0.5}$$ **iii)** **Steady state error for i/p, r(t) = 1 + 4t +t²/2** $$\boldsymbol{R(S)} = \frac{\mathbf{1}}{\boldsymbol{S}} + \frac{\mathbf{4}}{\boldsymbol{S^2}} + \frac{\mathbf{1}}{\boldsymbol{S^3}} = \frac{\boldsymbol{S^2}+\mathbf{4}\boldsymbol{S}+\mathbf{1}}{\boldsymbol{S^3}}$$ $$\boldsymbol{e_{ss}} = \lim_{s\to 0} \frac{\boldsymbol{S\ R(S)}}{\mathbf{1}+\boldsymbol{G(S)H(S)}} = \lim_{s\to 0} \frac{\frac{S^2+4S+1}{S^2}}{1+\frac{10\ (S+1)}{S^2(S+2)\ (S+10)}}$$	**1 M** **3 M** **4M**

$$e_{ss} = \lim_{s\to 0} \frac{\frac{S^2+4S+1}{S^2}}{\frac{S^2(S+2)(S+10)+10\,(S+1)}{S^2(S+2)\,(S+10)}} = \lim_{s\to 0} \frac{(S^2+4S+1)(S+2)\,(S+10)}{S^2(S+2)(S+10)+10\,(S+1)} = \frac{1\times2\times10}{10} = 2$$

$$e_{ss} = 2$$

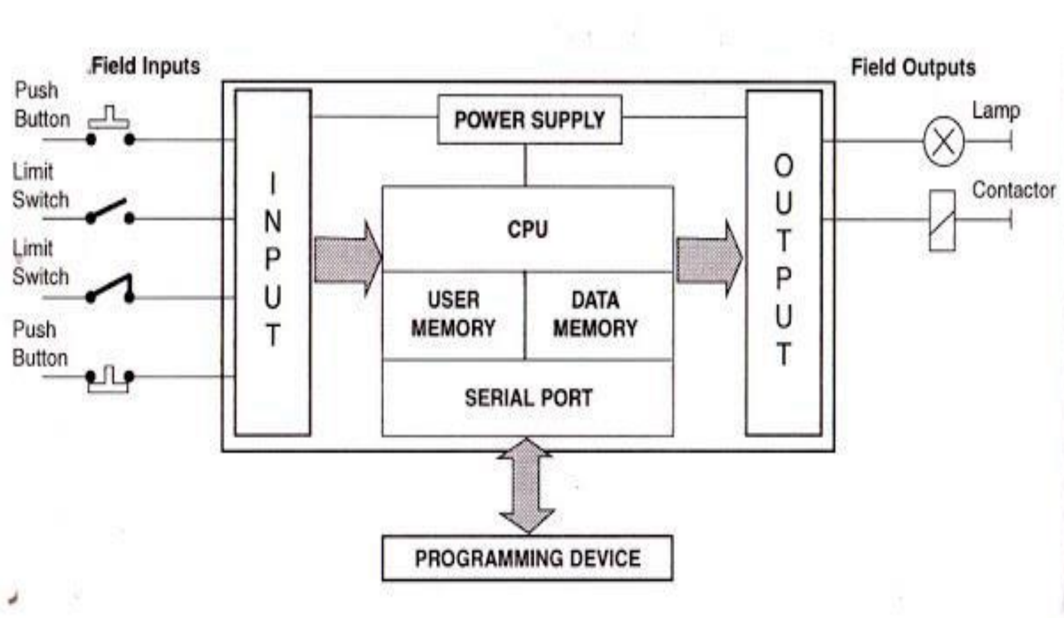
	c)	**Draw block diagram of PLC. Write function of each block.**	**8 M**

Ans:



4M

OR

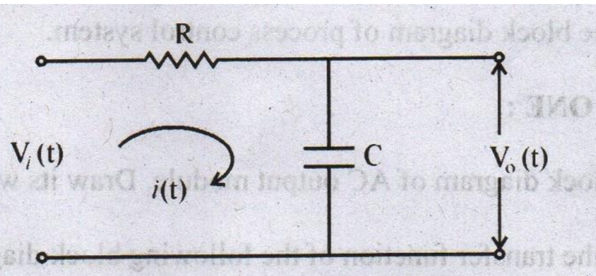


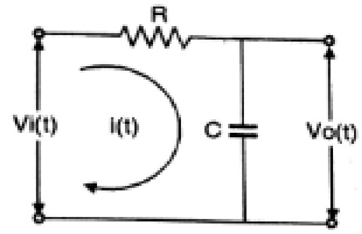
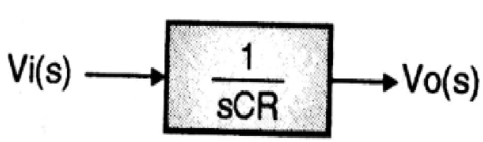
Explanation:

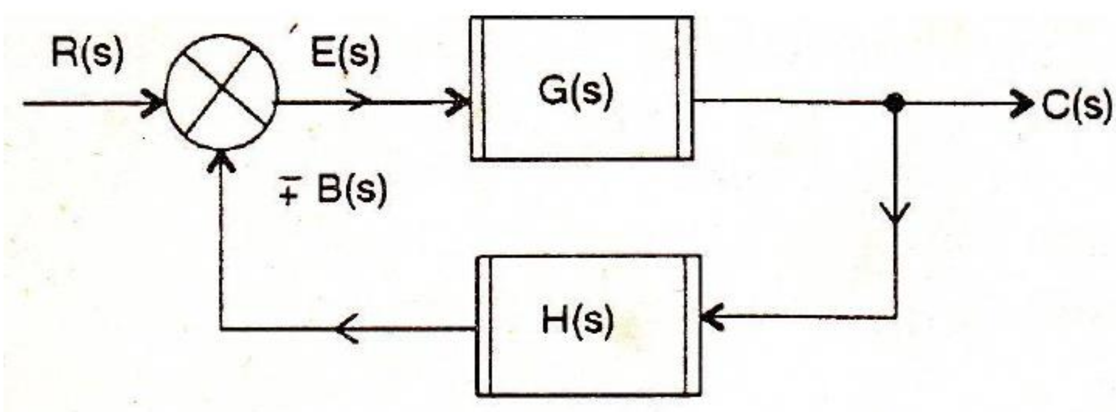
The Basic PLC structure consists of –

1) Input Module:
   Input Module works as an interface between the CPU and the real world input devices attached to input module .The devices connected to input module are called as input devices. It accepts the incoming signal and converts this signal in the form which is compatible with CPU.

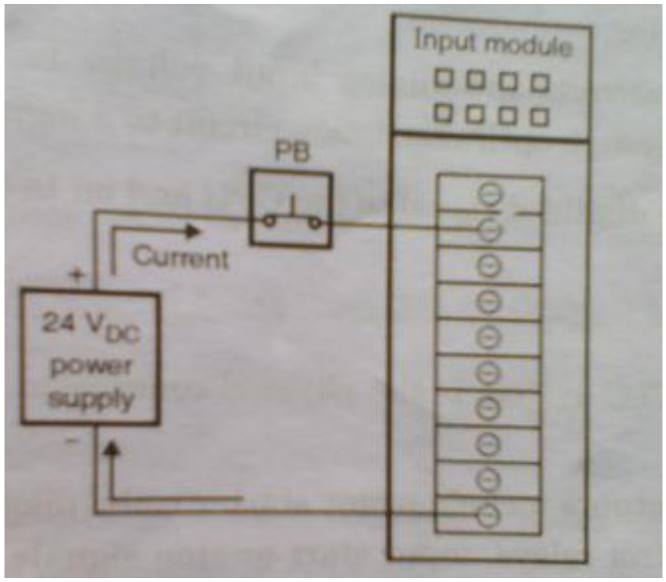
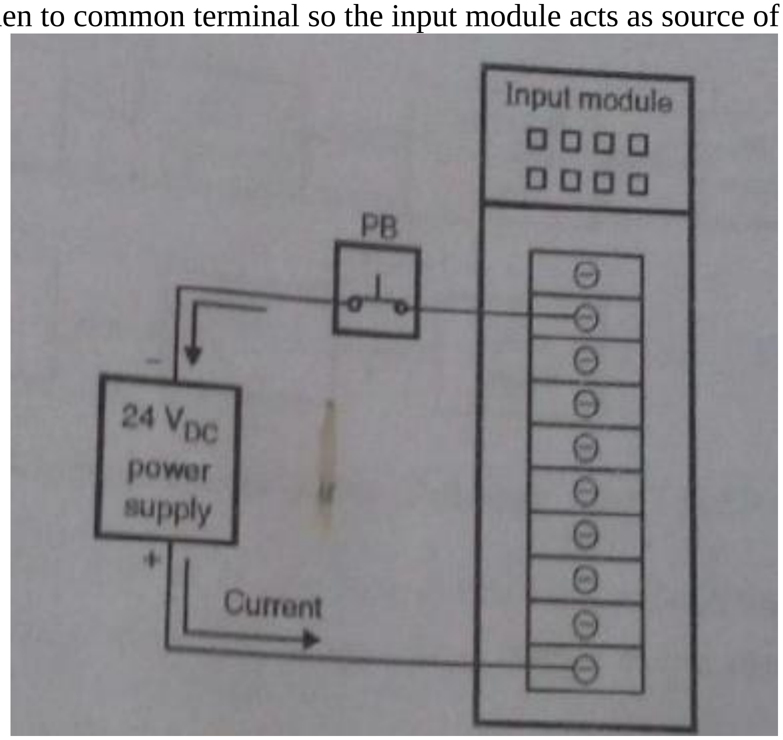
4M

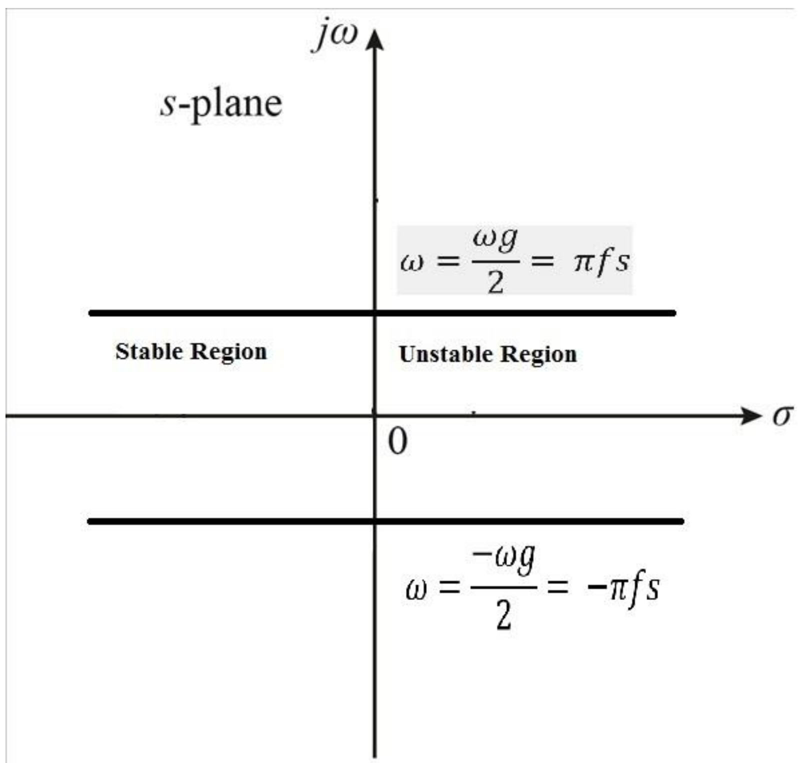
		2) Output Module: Output module works as an interface or link between the CPU and the real world devices attached to the output module. The main function of output module is to take control signal from CPU and based on signal received from CPU it changes the status of output devices. 3) Central processing unit: The CPU is the main part of any PLC .The CPU solves the user program logic, by using real time input status from input module and updates the status of outputs through output module. 4) Power supply: Power supply is the part of PLC which is used to supply required amount of power to CPU, input module and output module. 5) Programming device: The programming device is used for communication between user and PLC. The programming device help the user to enter and modify the required program into the PLC memory and troubleshoot PLC ladder logic program. 6) Memory: PLC memory is divided in two part, Data memory and User memory. Data memory is used to store data associated with instruction address and user memory is used to store user's application program.	
Q. 3		**Attempt any FOUR :**	**16 - Total Marks**
	a)	**Derive the transfer function of given network. Refer fig. – 2**  **Fig. 2**	**4 M**

	Ans:	 **R-C circuit** • Transfer function of the circuit is defined as, $L\frac{\{Output\}}{\{Input\}} = \frac{L\{V_o(t)\}}{L\{V_i(t)\}} = \frac{V_o(s)}{V_i(s)}$ From figure apply KVL to input loop we get, $V_i(t) = R_i(t) + \frac{1}{C}\int i(t)dt$ $V_o(t) = \frac{1}{C}\int i(t)\,dt$ • Neglecting initial conditions, taking Laplace of $V_i(t)$ and $V_o(t)$ we get, $V_i(s) = R \cdot I(s) + \frac{1}{sC} \cdot I(s)$ $V_o(s) = \frac{1}{sC} \cdot I(s)$ $I(s) = sC \cdot V_o(s)$ Substituting value of I(s) in Equation (1.6.9) we get, $V_i(s) = R \cdot sC \cdot V_o(s) + V_o(s)$ $V_i(s) = V_o(s)[1 + sCR]$ $\frac{V_o(s)}{V_i(s)} = \frac{1}{[1 + sCR]}$ Where RC is a time constant • The above system can be represented as shown below,  	**4 marks for transfer function**

	b)	**Describe the role of PLC automation.**	**4 M**
	Ans:	• 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) • Higher productivity. • Superior quality of end product. • Efficient usage of energy and raw materials • Improved safety in working conditions.	**1 mark each role (any four)**
	c)	**Define transfer function. Derive the expression of T.F. of closed loop system.**	**4 M**
	Ans:	Transfer Function is defined as the ratio of Laplace transform of output variable to that of input variable under the zero initial condition. The transfer function for a general closed loop control  R(s) – Laplace of reference i/p R(t). C(s) – Laplace of controlled o/p C (t). E(s) – Laplace of error signal e (t). B(s) – Laplace of feedback signal b (t). G(s) – Equivalent forward path transfer f_n . H(s) – Equivalent feedback path transfer function. Referring to this Fig. E(s) = R(s) ± B(s)-----------(1) B(s) = C(s) H(s) -----------(2) C(s) = E(s) G(s) ------------(3) B(s) = C(s) H(s) and substituting in equation (1) E(s) = R(s) ± C(s) H(s) E(s) = C(s) / G(s) C(s) / G(s) = R(s) ± C(s) H(s) C(s) = R(s) G(s) ± C(s) G(s) H(s) Hence, C(s) [1 ± G(s) H(s)] = R(s) G(s) C(s) / R(s) = G(s) / [1± G(s) H(s)]	**Definition 1 Marks, Diagram 1 M, derivation 02 M**

d)	**For system, characteristics equation is $s^4 + 22s^3+10s^2+s+k=0$. Find K.**	**4 M**
Ans:	1) Firstly Find even & odd coefficient from characteristics equation $S^4 + 22S^3 + 10S^2 + S + K$ 2) The routh's array for above characteristics equation is formed as follows S^4 1 10 K S^3 22 1 0 S^2 9.95 K 0 S^1 $\frac{9.95-22K}{9.95}$ 0 S^0 K 3) For stability all elements of 1st column of routh array should be positive. Consider Row s1 … $\frac{9.95-22K}{9.95} > 0$ i.e $K < \frac{9.95}{22}$ i.e. $0 < K < 0.45$ Thus K_{max} is 0.45 for stable system.	**03 marks for rouths array** **01 mark For K**
e)	**Define the term scanning cycle, speed of execution in PLC.**	**4M**
Ans:	**Scanning cycle** The processor controls the operating cycle or processor scan. This operating cycle consists of a series of operations performed Sequentially and repeatedly. Input scan: During input scan, the CPU scans (examines) the external input devices. The ON or OFF input states are stored in the input status table. Program scan: During the program scan, the processor scans the instructions in the control program, uses the input status from the input status file and determines if an output will or will not be energized Output status: During output scan, the processor writes ON or OFF status, one word at a time, to the associated output module. The operating cycle typically takes 1 to 25 millisecond. The input and output scan are normally short, relative to the time required for the program scan. **Speed of execution** "Speed at PLC scans memory and executes instructions is **speed of execution**" • A period between one I/O update and the next is termed as "One scan" • Time taken by PLC to update one of I/O terminal is Scan time • Scan time is generally measured in msec. • Speed of execution depends on speed of CPU, length of ladder diagram, types of instruction used in program. • Slower the CPU speed or longer the ladder diagram, takes more time to execute the program	**2 marks each term**

Q. 4	A)	Attempt any THREE :	12-Total Marks
	a)	**Explain with diagram sinking and sourcing concept in DC input modules.**	**4 M**
	Ans:	**Sinking Input Module:**  Figure, Shows sinking i/p module where current from positive terminal of DC power supply flows first from i/p device to i/p module and then to common terminal. So here, input module is sinking current from input device so it is sinking input module. **Sourcing input module:** The interface diagram of PLC input module as sourcing is shown in figure. In operation, PLC input module as sourcing, current from power supply first flows from input module to load and then to common terminal so the input module acts as source of current. 	**1 M for diagram & 1 M for explana tion** **1 M for diagram & 1 M for explana tion**

	b)	**Define . Give its S-plane representation.**	**4 M**
	Ans:	**Definition :** **Poles :** The values of ‘s’ which makes the transfer function infinity after substitution in the denominator of a transfer function are called poles of the transfer function. **Zeros :** The values of ‘s’ which makes the transfer function zero after substitution in the numerator of a transfer function are called zeros of the transfer function. System stability is determined from the location of closed loop poles in the s- plane. If the poles are located on the left half of s-plane, then such system is absolutely stable. If the poles are located on the right half of s-plane, then such system is unstable. If one or more pairs of non- repeated roots are located on the jw axis, then the system is critically stable or marginally stable  	**1 M** **1M** **2M**
	c)	**Compare proportional and integral controller on the basis of equation, advantages, response to error and application.**	**4 M**

Ans:

Parameters	Proportional controller	Integral Controller
Equation	$P_{out} = K_p E_p + P_0$ $P_{out} \rightarrow$ Controller output $E_p \rightarrow$ Error Percentage $K_p \rightarrow$ Propornality constant $P_0 \rightarrow$ Controller Output at SP	$P_{out} = K_i \int_0^t E_p dt + P_0$ $P_{out} \rightarrow$ Controller output $E_p \rightarrow$ Error Percentage $K_i \rightarrow$ Integral constant $P_0 \rightarrow$ Controller Output at SP
Advantage (any one)	1.looks into present error 2.moderate response speed 3.moderate stability	1.looks into Past history of error 2.eliminates noise 3.eliminates Offset
Response to error	Response to direction of error. Controller output α to error.	Response to magnitude of error i.e. size and time duration. Rate of change of output α error
Application	In inner loop cascade control	Robotic arm movement

1M for each comparison.

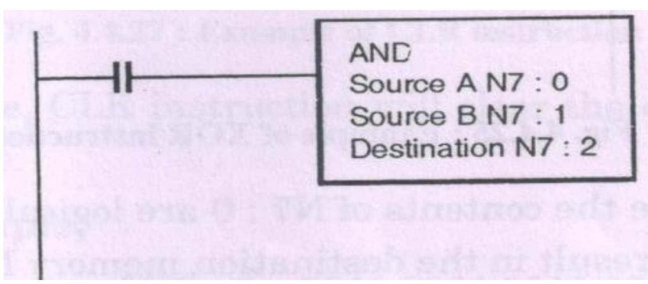
d) Write any four logical instructions in PLC **4 M**

Ans:

1 mark each instruction. Any four instruction (description is not expected)

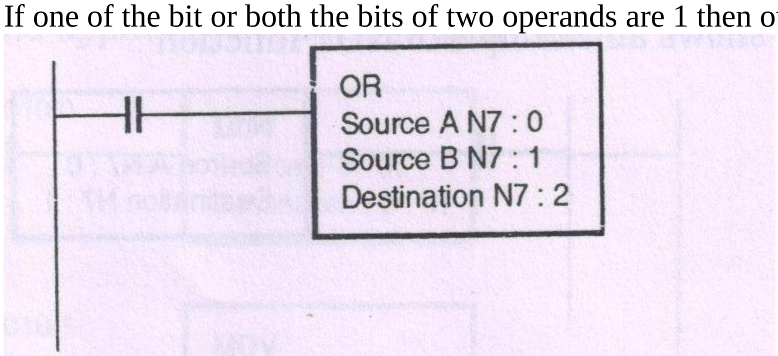
1. AND instruction:

It performs the logical AND operation between two operands.



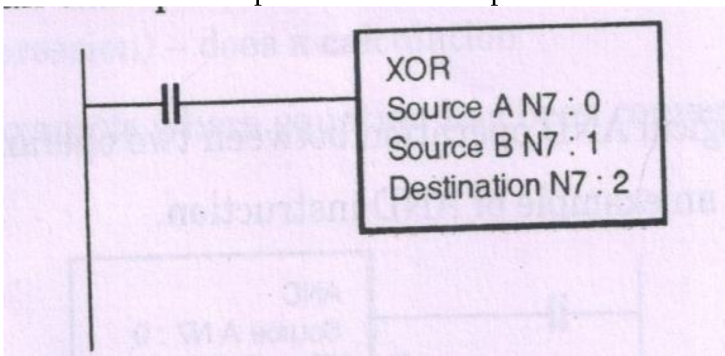
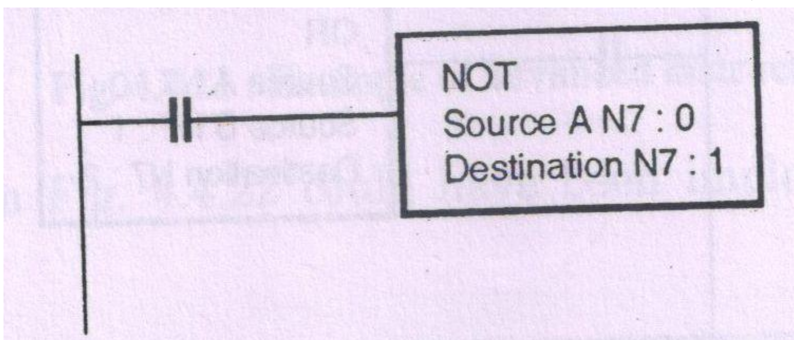
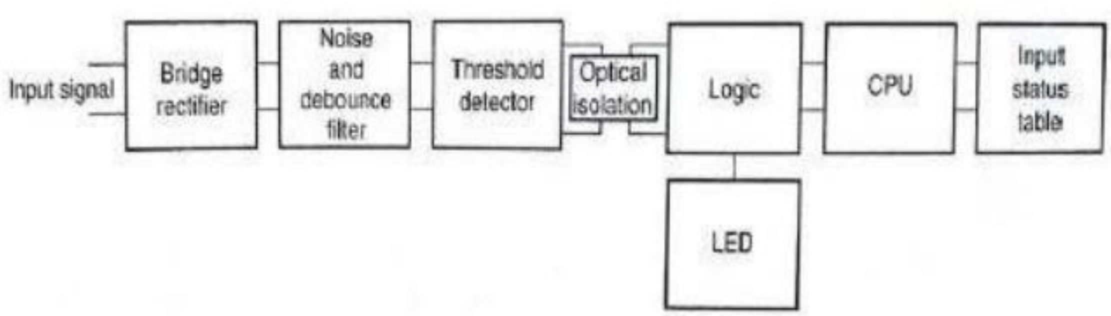
2. OR instruction:

It performs the logical OR operation between two operands.
If one of the bit or both the bits of two operands are 1 then output bit is 1 otherwise 0.



3. XOR instruction:

It performs the logical EX-OR operation between two operands.

		If odd number of inputs are 1 then output of EX-OR is 1 otherwise 0  4. NOT instruction: It has single source and perform logical NOT operation and store result in destination memory. Output is complement of input. NOT instruction reverses all of the bits in the source word. 	
	B)	**Attempt any ONE :**	**6 -Total Marks**
	a)	**Draw block diagram of AC input module.**	**6 M**
	Ans:	 Block diagram of a typical AC input circuit.	**6 marks**
	b)	**Describe PID control action w.r.t. equation and response to error.**	**6 M**
	Ans:	PID controller is the proportional-integral-derivative controller. A PID controller calculates an "error" value as the difference between a measured process variable and a desired set point. The controller attempts to minimize the error by adjusting the process control inputs.	**3 marks each**

Equation: $P_{out} = K_P E_p + K_P K_I \int_t E_p(t)d(t) + K_P K_D \frac{d}{dt} E_p + P_0$
K_P = proportional gain
E_p = error percentage
K_I = integral gain
K_D = derivative gain
P_0 = controller output at time t = 0

When an error is introduced to a PID controller, the controller's response is a combination of the proportional, integral, and derivative actions. Assume the error is due to a slowly increasing measured variable. As the error increases, the proportional action of the PID controller produces an output that is proportional to the error signal. The integral action of the controller produces an output whose rate of change is determined by the magnitude of the error. In this case, as the error continues to increase at a steady rate, the integral output continues to increase its rate of change. The derivative action of the controller produces an output whose magnitude is determined by the rate of change. When combined, these actions produce an output. The output produced responds immediately to the error with a signal that is proportional to the magnitude of the error and that will continue to increase as long as the error remains increasing.

The proportional action of the controller stabilizes the process. The integral action combined with the proportional action causes the measured variable to return to the set point. The derivative action combined with the proportional action reduces the initial overshoot and cyclic period.

Q.5		**Attempt any TWO :**	**16 - Total Marks**
	a)	**List and explain the timer instructions of PLC.**	**8 M**

Ans:

Depending on the time delay and operation there are two types of timers PLC timer
- (i) ON delay timer
(ii) OFF delay timer

ON delay timer **4M**

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

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.

The accumulated value is reset when the rung condition go false regardless of whether the timer has timed out Instruction parameter- Timer TON is 3 word element.

	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- 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.

OFF delay timer **4M**

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 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 TOFF is 3 word element.

	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	Accumulat or 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 (bit1S)-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.

b) **Consider the system with characteristic equation.**
$S^4+6S^3+26S^2+56S+80=0$.
Determine stability of the system using Rout's Criteria. **8 M**

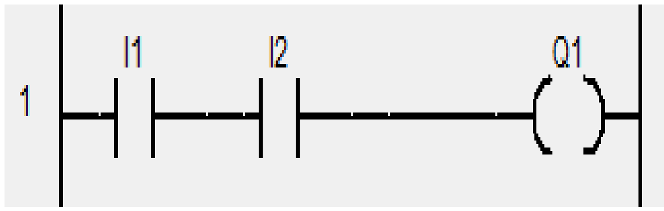
<table>
<tr><td></td><td>Ans:</td><td>Given Characteristic equation is
$s^4 + 6s^3 + 26s^2 + 56s + 80 = 0$
Find odd and even coefficients from given characteristic equation and ma
Rouths array
$a_0 = 1 \quad a_1 = 6 \quad a_2 = 26 \quad a_3 = 56 \quad a_4 = 8$
Make Rouths array
s^4 : 1   26   80
s^3 : 6   56
s^2 : 16.6   80
s^1 : 27.08
s^0 : 80
$b_0 = \frac{6 \times 26 - 1 \times 56}{6} = 16.6$
$b_1 = \frac{6 \times 80 - 0}{6} = 80$
$c_1 = \frac{16.6 \times 56 - 80 \times 6}{16.6} = 27.08$
As there is no change in the sign in the first column of Rouths array, the system is stable</td><td>6M

2M</td></tr>
<tr><td></td><td>c)</td><td>A unity feedback system has
$G(S) = \frac{40(S+2)}{S(S+1)(S+4)}$
Determine all error coefficients.</td><td>8 M</td></tr>
</table>

	Ans:	Q5. c Given $G(s) = \frac{40(s+2)}{s(s+1)(s+4)}$ and $H(s) = 1$ Converting $G(s)H(s)$ into standard form $\frac{40 \cdot 2(1+0.5s)}{s(1+s) \cdot 4(1+0.25s)}$ $G(s) \cdot H(s) = \frac{20(1+0.5s)}{s(1+s)(1+0.25s)}$ i) Positional error coefficient $K_p = \lim_{s \to 0} G(s) \cdot H(s)$ $= \lim_{s \to 0} \frac{20(1+0.5s)}{s(1+s)(1+0.25s)}$ $K_p = \infty$ ii) Velocity error coefficient $K_v = \lim_{s \to 0} s \cdot G(s) \cdot H(s)$ $= \lim_{s \to 0} \frac{s \cdot 20(1+0.5s)}{s(1+s)(1+0.25s)}$ $K_v = 20$ iii) Acceleration error coefficient $K_a = \lim_{s \to 0} s^2 \cdot G(s) H(s)$ $= \lim_{s \to 0} \frac{s^2 \cdot 20(1+0.5s)}{s(1+s)(1+0.25s)}$ $K_a = 0$	**2M** **2M** **2M** **2M**
Q.6		**Attempt any FOUR:**	**16-Total Marks**
	a)	**Draw the ladder diagram for** **i) AND gate** **ii) NAND gate**	**4 M**

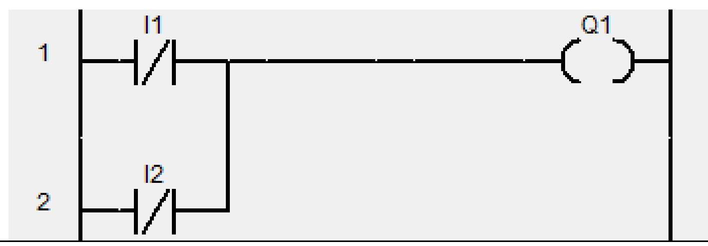
Ans: **AND Gate for I1 & I2 Inputs** **2M**

I1	I2	Q1
0	0	0
0	1	0
1	0	0
1	1	1



NAND Gate for I1 & I2 Inputs **2M**

I1	I2	Q1
0	0	1
0	1	1
1	0	1
1	1	0



b) State the Routh's stability criteria. **4 M**

Ans: The necessary & sufficient condition for system to be stable is "All the terms in the first column of routh array must have same sign. There should not be any sign change in the first column of Routh"s array". **4M**

If there are any sign changes existing then,

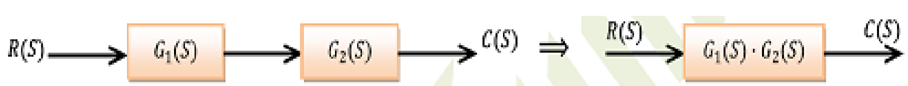
(1) System is unstable

(2) The number of sign changes equals the number of roots lying in the right half of the S- plane.

c) List any two rules of block diagram reduction technique. **4 M**

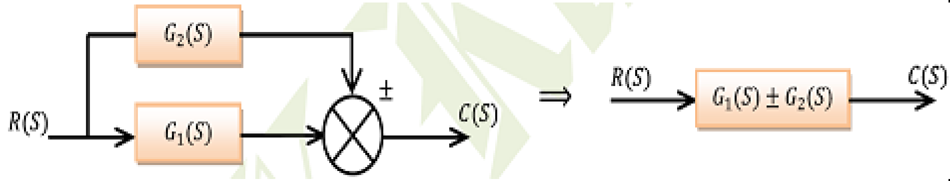
Ans: **Any Two Rules 2M for each**

i) Combining a block in cascade: When two or more blocks are connected in series, their overall transfer function is the product of individual block transfer function.

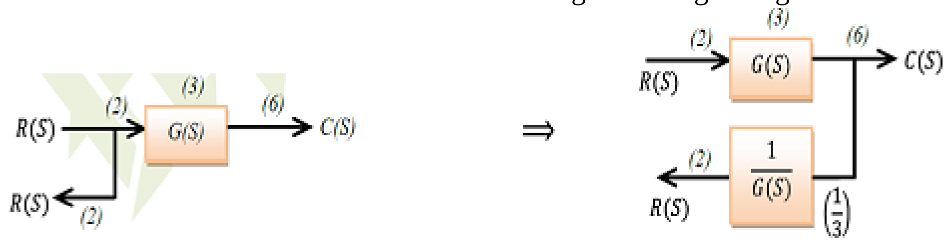


ii) Combining two blocks in parallel: When two or more blocks are connected in parallel, their overall transfer function is the addition or difference of individual transfer function

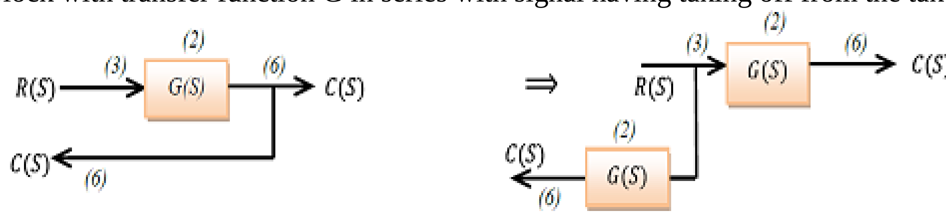
iii) Shifting a take-off point after a block: To shift take off point after a block, we shall add a block with transfer function 1/G in series with signal having taking off from that point.



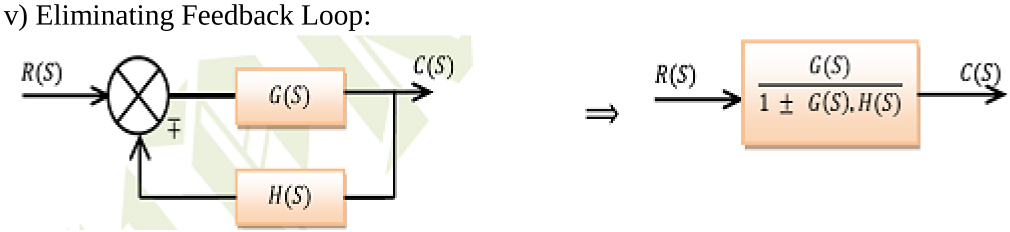
iii) Shifting a take off point after a block: To shift take off point after a block, we shall add a block with transfer function 1/G in series with signal having taking off from that point.



iv) Shifting a take off point before a block: To shift take off point before a block, we shall add a block with transfer function G in series with signal having taking off from the take off point

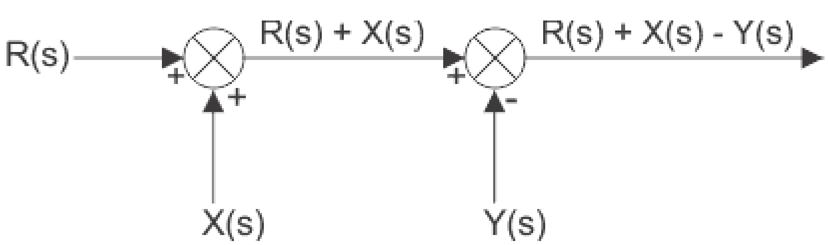


v) Eliminating Feedback Loop:

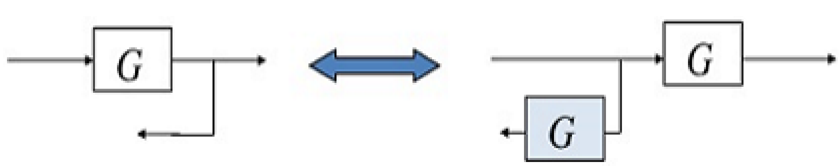


$$\frac{C(s)}{R(s)} = \frac{G(s)}{1 \pm G(s).H(s)}$$

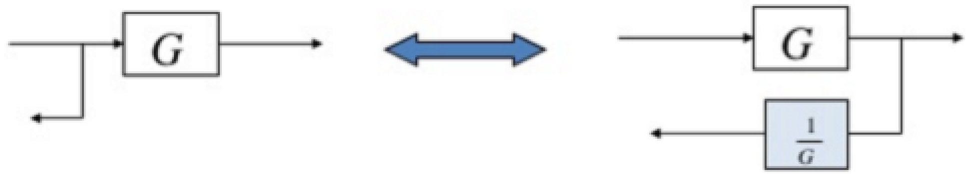
vi) Interchanging Summing Points: The order of summing points can be interchanged, if two or more summing points are in series and output remains the same



vii) Moving Take off point before a summing point: To shift a take off point before summing point, add a summing point in series with take off point.



viii) Moving Take off point after a summing point: To shift a take off point after summing point, one more summing point is added in series with take off point.



ix) Moving summing point after a block: To shift summing point after a block, another block having transfer function G is added before the summing point.
x) Moving summing point before a block: To shift summing point before a block, another block having transfer function 1/G is added before the summing point.

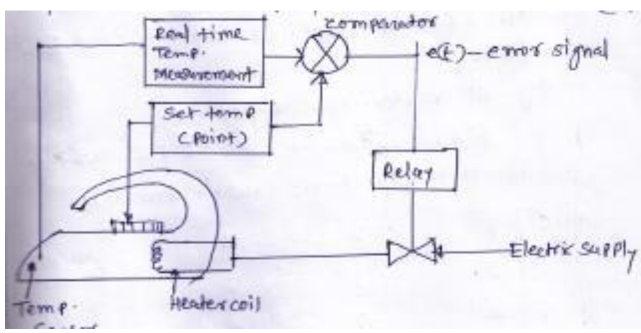
d) Explain on – off controller with neat diagram. **4 M**

Ans: This is the most elementary controller mode which has only two fixed position ON and OFF . positions are commonly used two positions in most of the control systems. **2M**

In this mode, when the error signed e(t) greater than the set point r(t), the output minimizes When the error signal is less than the set point the output maximizes.

Fig (1) shows an iron which is an example of the ON/OFF control action, in this system there are only two stages of the output i.e. either the heater coil turn ON or OFF.

In this the real time temperature is compared with the set point and error signal is generated by the controller to activate the relay, which ON/OFF the coil supply.



2M for any relevant example

e) Compare open loop and closed loop system **4 M**

Ans: **1 mark for each point (Any 04 points)**

Sr. No	**Open Loop Control System**	**Close Loop Control System**
1	It is simple and economical	It is complex and costlier
2	It is easier to construct, as it requires less number of components	It is not easy to construct, as it requires more number of components
3	It consumes less power	It consumes more power
4	It is more stable	It is less stable
5	It does not require feedback path element	It requires feedback path element
6	It has poor accuracy	It has better accuracy
7	It does not give automatic correction for external disturbances	It gives automatic correction for external disturbances
8	It is more sensitive to noise	It is less sensitive to noise
9	It is dependent on operating condition	It is not dependent on operating conditions
10	Its operation is degraded if non	Its operation is not independent on

	linearity is present	conditions	
11	It has slow response	It has fast response	
12	It has high bandwidth	It has low bandwidth	