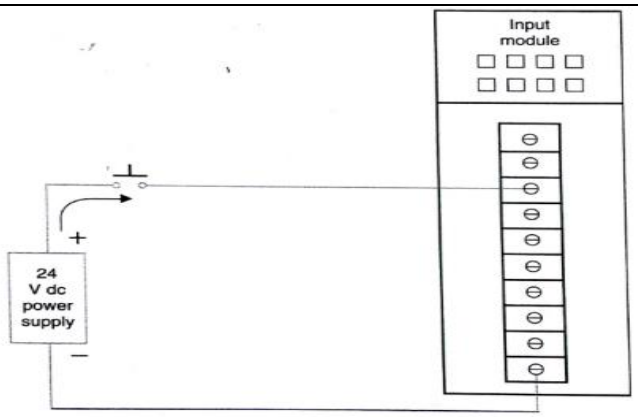
Important Instructions to examiners:

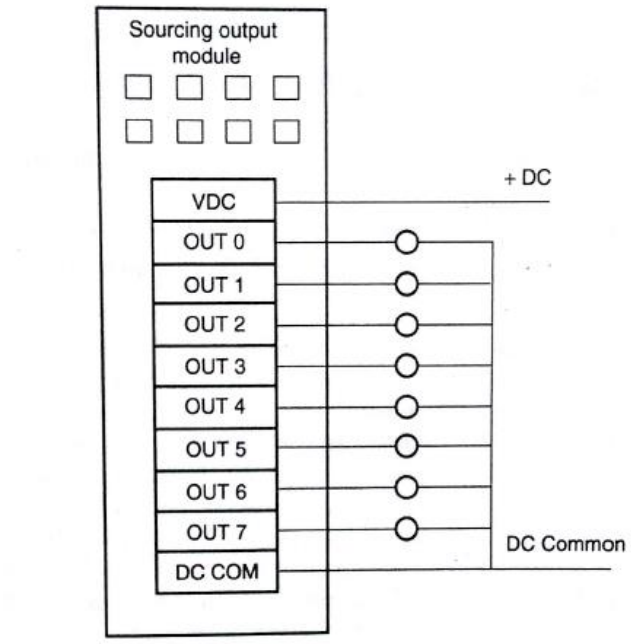
1) The answers should be examined by keywords and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling 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**
(i)	**List any four benefits of automation.**		**04**
Ans.	Automation provides following Benefits: 1. Increased Productivity. 2. Improved Product quality. 3. Increased Accuracy. 4. Reduced Manpower. 5. Reduction in personal injury or accidents. 6. Reduction in the cost of product due mass production. 7. Increased profit. 8. Achieves consistency in the manufacturing. 9. Centralized control of plant is possible. **Note: Any relevant four benefits should be considered**	**01 mark for each point (any four)**	
(ii)	**Draw wiring diagram of sinking input module and sourcing output module.**		**04**
Ans.	1. Typical Wiring diagram of Sinking input Module:	**02 marks**	



Sinking DC input module with a sourcing switch.

2. Typical wiring diagram of Sourcing output module:

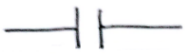


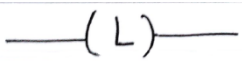
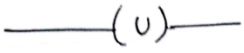
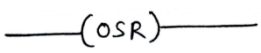
Sourcing output module interface to field devices.

OR

Note: Sinking i/p module & sourcing o/p module combined wiring diagram should be considered.

02 marks

(iii)	**List four relay type instructions of PLC with symbols.**		**04**
Ans.	1. Normally open or examine if ON (N/O) Symbol:  2. Normally closed or examine if OFF (N/C)	**01 mark for each symbol (any four)**	

	Symbol:  3. Output enabled (OTE): Symbol:  4. Latch output Symbol:  5. Unlatch output Symbol:  6. One shot rising Symbol:  **Note: Any relevant four symbols should be considered**		
(iv)	**List any four I/o module selection criteria.**		**04**
Ans.	Following points must be considered while selecting I/O modules: 1. System Requirement. 2. Application requirement. 3. What input /output capacity is required. 4. What types of input/output are required? 5. Electrical requirements. 6. Speed of operation. 7. Communication Requirements. 8. Software Requirements. 9. Operator interface requirements. 10. Physical environment. **Note: Any relevant four points should be considered**	**01 mark for each point(four points)**	
(b)	**Attempt any ONE of the following**		**06**
(i)	**1) Differentiate between relay control and PLC control (any two points)**		**06**

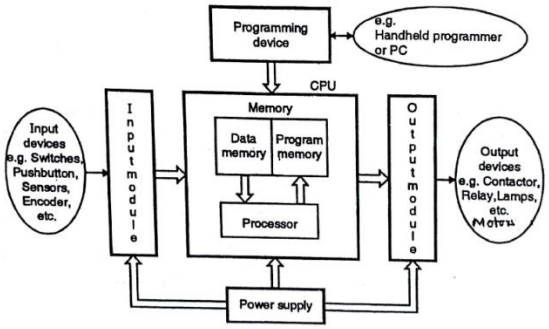
	2) Draw block diagram of PLC and explain function of CPU.		
Ans.	1) Differentiate between relay control and PLC Control	**01 mark each point (any three points)**	

Parameter	Conventional Control	PLC-Based Control
Tool used for automation	Hard wiring.	Software programs.
Space requirements	Requires a large amount of space to house the relays and the connecting wires.	Compact systems and can be installed in much smaller space.
Power consumption	Higher power consumption. Approximate power requirement for a contactor consisting of 500 I/O devices is 220 volts x 0.2 amps x 500 = 22 KVA.	Much lower power consumption. Approximate power requirement for a PLC controlling 500 I/O devices is 0.1 KVA. This is because PLCs do not require hard wiring and actual circuits for controlling the operations.
Installation	The installation process is very difficult as the individual relays first need to be made using electronic circuits and then connected using hard wiring. Each relay needs to be tested individually for proper functioning.	The installation process is much easier and the controls can be easily programmed using the ladder logic and tested in a simulated environment. In addition, the installation of PLCs can be made modular. In other words, different parts of a process can be automated in different phases.
Maintenance	Regular wear and tear of relay and hard wire takes place. As a result, extensive maintenance of the system is required.	As the software program is not subject to wear and tear, not much effort is required in normal maintenance. Only the cables connecting the real-world devices to the PLC need to be maintained.
Flexibility	Not very adaptable to changes. Any change in the process requires shutting down the entire system and adding/removing the concerned relays.	Very adaptable to change. To change a process, a modification in the program is required. The modified program can be tested outside the system, and after the robustness of program is checked, the program can be installed in the system.
Reliability	Prone to mechanical faults and other failure.	Highly reliable as there are much lesser chances of mechanical failures.
Diagnosing problems	Very difficult to diagnose problems because each concerned relay and its wiring needs to be examined manually.	Easy to diagnose problems as the software contains options for troubleshooting and diagnosing the problems. A check needs to be performed on the software and the required bug can be easily fixed.

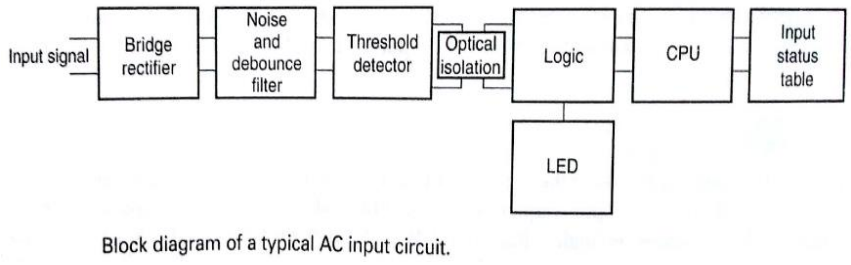
2) Draw block diagram of PLC and explain Function of CPU

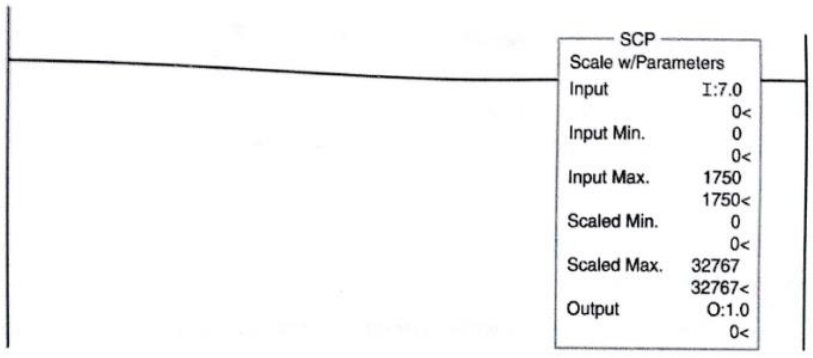
Block diagram of PLC

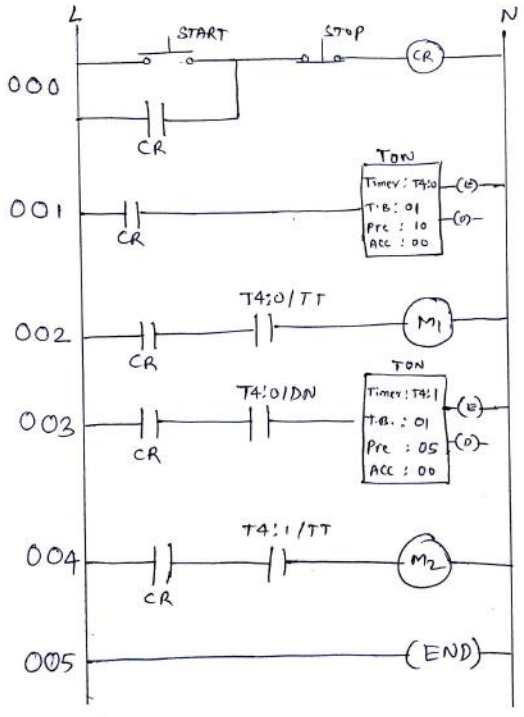
01 mark for block diagram

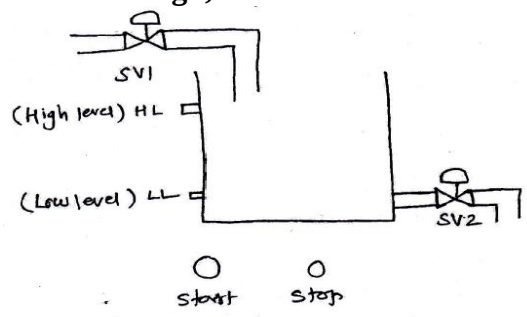


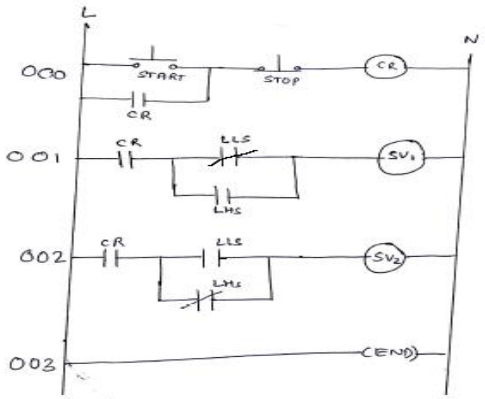
Block diagram of PLC

	Function of CPU CPU or the central processing unit 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 output module. The CPU consists of – (i) Processor, (ii) Memory. The processor is responsible for the complete program scan in a PLC. During Program scan processor communicate with the memory. Memory is used in CPU are of two types RAM and ROM. RAM memory is used to store the data related to input status, output status, timers, counters, internal bit relay, numerical values etc. ROM memory is to store system program and user program.	**02 marks for explanation**	
(ii)	**Draw block diagram of AC input module and explain function of each block.**		**06**
Ans.	**Block diagram of AC input module:**  Block diagram of a typical AC input circuit. **Explanation:** **Power conversion:** The power conversion section usually consists of resistors and bridge rectifier. The bridge rectifier converts the incoming AC signal to a pulsating DC level. The DC level is passed through filters and other logic circuits in order to deliver a clean, debounced , DC input signal. The filtered DC signal goes on to the threshold detector. **Threshold detection:** Threshold detection circuitry detects if the incoming signal has reached or exceeded a predetermined value for a predetermine time, and whether it should be classified as valid ON or OFF signal. **Isolation:** Isolation section of the input ckt. Is usually made up of an optical isolator, or opt coupler. In a 120VAC input module, isolation	**03 marks for block diagram** **03 marks for explanation**	

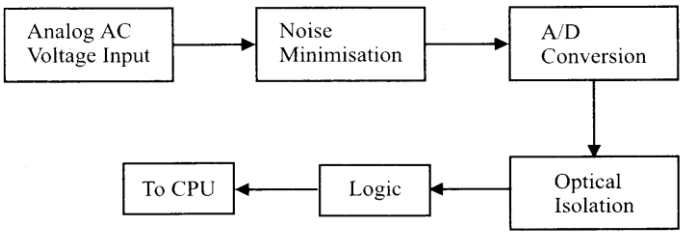
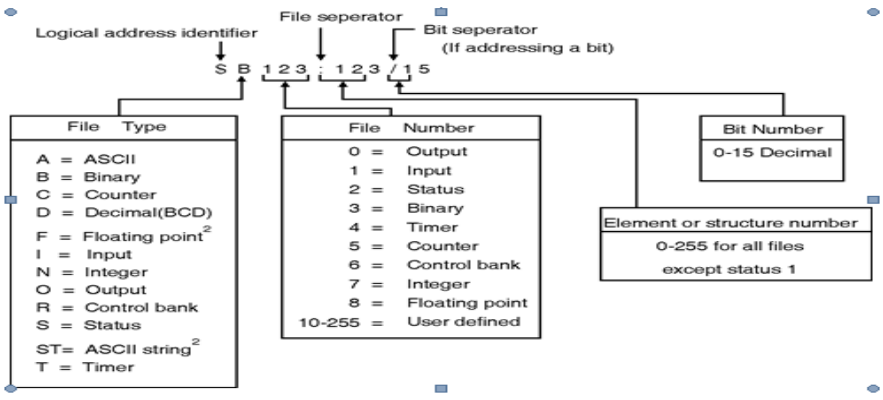
	separates the high voltage, 120VAC input signal from the CPUs low voltage control logic. **Logic section:** DC signal from the opto coupler are used by the logic section to pass the input signal to the module's input address LED and the CPU and then on to the input status file.		
2	**Attempt any TWO of the following**		**16**
a)	**(i) State types of PLC programming languages.** **(ii) Explain format of SCP (Scale with Parameters) instruction of PLC.**		**08**
Ans.	**(i) State types of PLC programming Languages–** following are the types of PLC programming languages: 1. Function block diagram (FBD) 2. Ladder diagram (LD) 3. Structured Text (ST) 4. Sequential function chart(SFC) 5. Instruction list(IL) **(ii) Explain format of SCP (Scale with Parameter) instruction of PLC.** **Symbol of SCP instruction:**  The scale with parameters instruction scaling the input value of 0 to 1750 to 0 to 32767. **Explanation:** The instruction parameters shown in above fig are explained as follows:	**01 mark for each type (Any relevant four type)** **02 marks for format** **02 marks for explanation**	

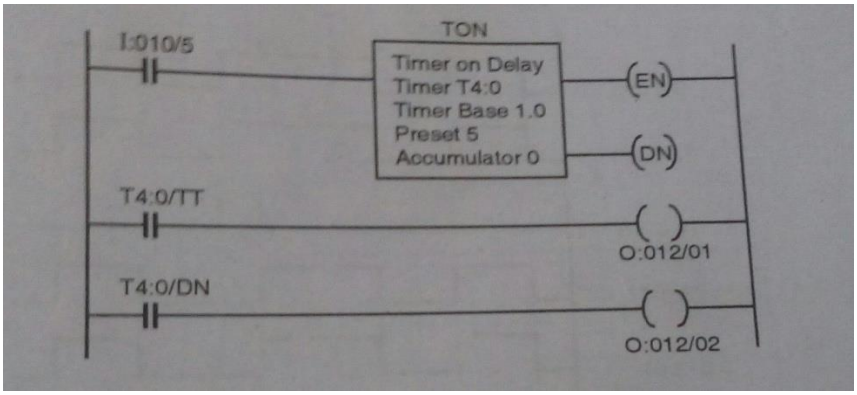
	Input: This is the input value to be scaled. It can be address, integer or floating point address. **Input min:** the input minimum is the minimum input value. **Input max:** Input maximum is the maximum input value. **Scaled min:** This represents the input scaled minimum value. **Scaled max:** scaled maximum is the scaled or converted maximum value. **Output:** Enter the address for the scaled input data to be output after instruction execution. This can be an address, integer or floating point address		
b)	**Draw ladder diagram for a two-motor system having following conditions:** **(i) Start push button starts motor M1** **(ii) After 10 sec. motor M1 is OFF and motor M2 is ON.** **(iii)After 5 sec. motor M2 is OFF** **(iv)STOP push button stops both motors M1 and M2 if pressed any time during process.**		**08**
Ans.	Ladder Diagram: **(Note: any other correct logic can also be considered for the program.)** 	**08 marks for ladder diagram**	

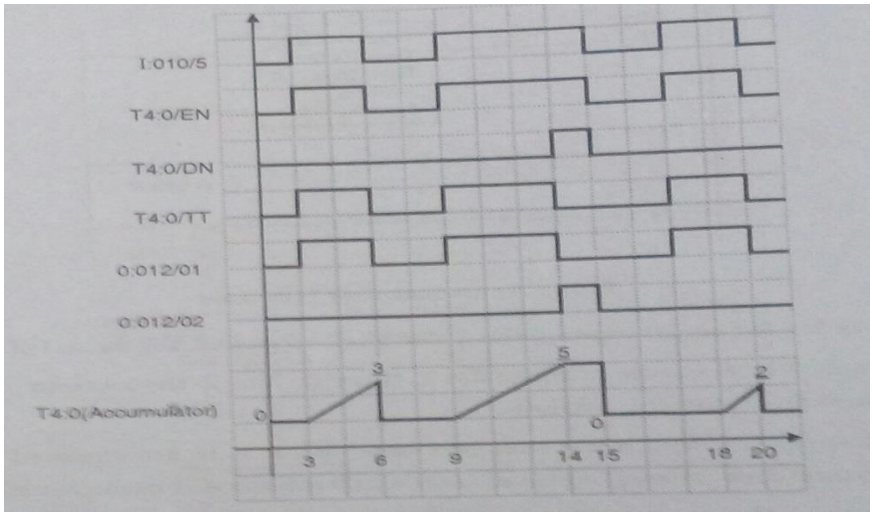
	Explanation: **Rung 000:** This rung is used as Latch rung. Internal control relay or Memory bit is latched. When start PB is Pressed. **Rung001:** When START PB is pressed, Timer T4:0 Starts timing towards 10 sec. **Rung 002:** For 10 sec. Time T4:0/TT bit remains closed and keeps Motor M1 On for 10 sec. **Rung003:** After 10 sec of T4:0, T4:0/DN bit becomes closed ND STARTS Timer T4:1. **Rung004:** for 5 sec time, T4:1/TT bit remains closed and keep motor M2 ON for 5 sec. After 5 sec motor M2 goes off. ■ When stop button is pressed during the process, the CR contact in each rung becomes open and stops M1 and M2 immediately.	**Explanation optional**	
c)	**(i) Which start button is pressed process starts, when stop button is pressed process stops?** **(ii) If level is low, SV1 is open and SV2 is closed.** **(iii)When level is high, SV1 is closed and SV2 is open.**  **Fig. No. 1**		**08**
Ans.	**(Note: any other correct logic can also be considered for the program.)**	**08 marks for ladder diagram**	

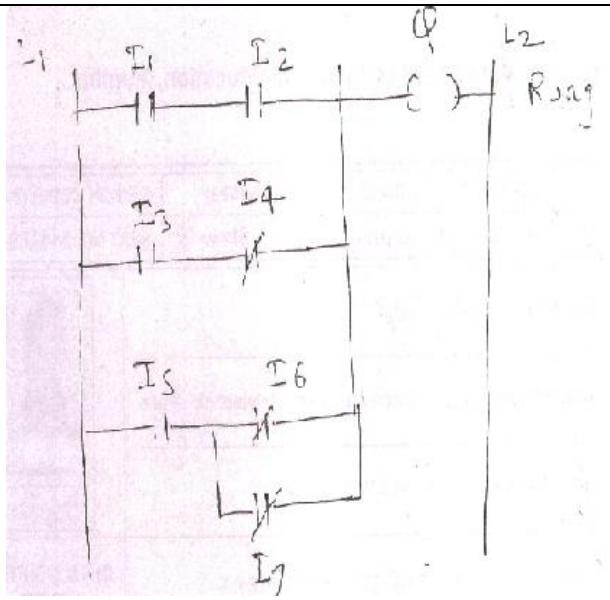
	 **Explanation:** **Rung 000:** This rung is used as Latch rung. Internal control relay or Memory bit is latched. When start PB is Pressed. **Rung 001:** When level is Low SV1 is open and SV2 is closed. **Rung 002:** When level is high SV1 is closed and SV2 is open ■ **When stop button is pressed during the process, the CR contact in each rung becomes open and stops M1 and M2 immediately.**	**Explanation optional**	
3	**Attempt any FOUR of the following**		**16**
a)	**State the classification of PLC based on type and explain.**		**04**
Ans.	**Classification of PLC based on type and size:** PLC : - A) Micro PLC (Fixed I/O) It is also called fixed PLC It is micro PLC because of its size It has fix I/O's, brick design All components are in a single package Effective use on smaller and stand alone application B) Modular PLC: - It is in modular in structure, its components are separate. Modules are installed in I/O rack.It has following types, i) Small PLC : It has limited expansion capabilities. Having 20 inputs and 12 outputs are mounted on rack. Additionally less than 100 I/O's can be added through remote I/O rack.	**01mark** **03 marks**	

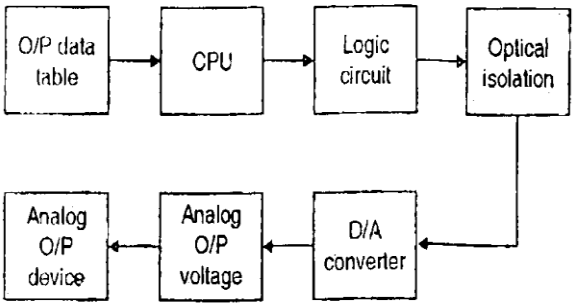
	ii) Medium PLC: In this components are separate, also include mathematical function, file function etc. It can have 4000 to 8000 I/o' iii) Large: It can hold multilplecards, can connected together as per requirement. It flexible and easy to maintain. It has I/O's more than medium PLC		
b)	**Expand abbreviation of following automation tools:** **(i) SCADA** **(ii) PLC** **(iii) DSC** **(iv) CNC**		**04**
Ans.	**1) SCADA: Supervisory control and Data acquisition system**. It is basically software, which runs on a central PC and connected to the different field devices in industry through PLC. It takes data from field, stores data and processed on it and send it to the field devices for controlling purpose. **2) PLC**: **Programmable logic controller.** It replaces relay logic used for automation in industry. It is digital system, can store program in memory, having timers, counters, special modules, I/O module, works in industrial environment. It stores process parameters, generate reports. **3) DCS: Distributed Control System :** • A distributed control system (DCS) is a control system for a process or plant, wherein control elements are distributed throughout the system. • This is in contrast to non-distributed systems, which use a single controller at a central location. In a DCS, a hierarchy of controllers is connected by communications networks for command and monitoring **4) CNC: Computer Numerical Control**. It is one in which the functions and motions of a machine tool are controlled by means of a prepared program containing coded alphanumeric data. CNC is widely used for lathe, drill press, milling machine, grinding unit, laser, sheet-metal press working machine, tube bending machine etc	**01 marks for each abbreviation** **(Explanation optional)**	

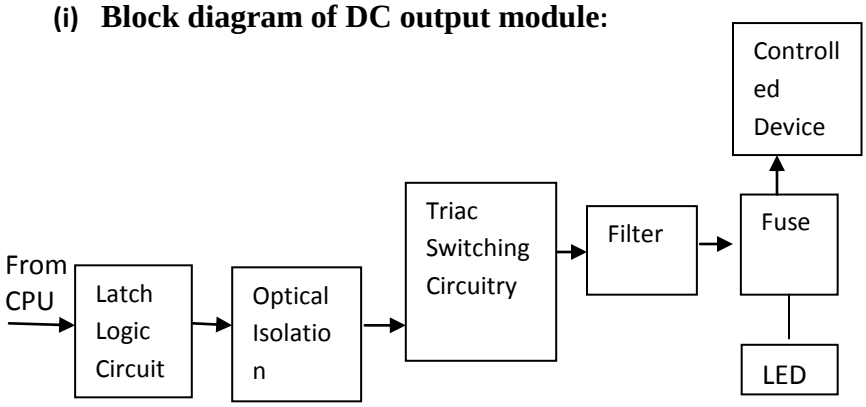
c)	**Draw the block diagram of analog input module and state the function of each block.**		**04**
Ans.	 Analog input module interface a PLC to analog input signals. It gives ability to PLC to monitor a continuously changing input signals such as pressure, temperature, flow etc. The module converts analog input signals to 16 bit binary values storage in the processor's input status table. Analog modules are designed to accept current and voltage signals such as 0-10 Vdc,-10-10 Vdc, 0-5Vdc and 0-20mA,4-20mA,- 20 -20mA etc. When signal reaches an input module,it is rich in different noise signals. **Noise minimization**:-The signal is freed from noise through noise minimization circuits. The signal is then digitized and sent to logic section through an isolation circuit. **A/D Conversion**:- It convert analog to digital signal required for further process. **Optical Isolation**: It is used to protect CPU from high voltage coming from fault in the input section. **Logic section**:-The logic section allows the digitized signal to go to the CPU following the predetermined logic	**02 marks for bock diagram** **02 marks for description**	
d)	**Give I/O addressing format for a typical PLC, with example.**		**04**
Ans.	 The addressing is necessary to deal with data files for their identification.	**02 marks for format of addressing**	

	It is identified by A letter called an identifier and a file number. The basic addressing elements include, type, slot, word and bit. Type: the type determine if an input or output being addressed Slot: the slot number is the physical location of the I/O module. This may be combination of rack number and slot number when using expansion of rack Word and bit: These are used to identify the actual terminal connection in a particular I/O module. For example:- I1:0/0, O0:2/5	**02 marks for example**	
e)	**Explain why grounding is necessary for PLC installation.**		**04**
Ans.	**Grounding:** Proper grounding is an important safety measure in all electrical installations. The authorative source on grounding requirements for a PLC installation is the National Electrical Code. The code specifies the type of conductors, color codes, and connections necessary for safe grounding of electrical components. According to the code, the grounding path must be permanent (no solder), continuous, and able to conduct safely the ground-fault current in the system with minimal impedance. In the event of a high value of ground current, the temperature of the conductor could cause the solder to melt, resulting in interruption of the ground connection. In addition to the grounding required for the controller and its enclosure, you must also provide proper grounding for all controlled devices in application.	**04 marks**	
4	**Attempt any THREE of the following:**		**12**
(i)	**Draw the format of TON instruction with timing waveforms.**		**04**
Ans.	Format of ON Delay timer: 	**02 mark for format**	

	Waveform:  **OR** **Note: Any other suitable format & waveform should be considered**	**02 marks for waveform**	
(ii)	**List types speciality I/o modules and explain any two.**		**04**
Ans.	Different types of speciality I/O modules: 1) Communication module 2) RTD input module 3) High speed encoder 4) Stepper motor control 5) Thermocouple input module 6) Remote I/O subscanner **1) Communication module: -** The communication modules are used to communicate with programming devices, displays, plant computers, other PLC's. The four common communication modules are ASCII modules, local I/O adapter modules, the serial data modules, network interface modules. **2) RTD input module: -** This module interfaces RTD's to a PLC and other types of resistance input devices such as potentiometers. It consists of bridge circuit filter, amplifier, and isolator circuits.	**01 mark for types** **03 marks for description of any two speciality I/o modules**	
(iii)	**Draw ladder diagram for Boolean equation,** **$Q= I_1.I_2+I_3.\bar{I}_4+I_5(\bar{I}_6+\bar{I}_7)$**		**04**

Ans.	 **Ladder diagram**	**04 mark for ladder diagram**	
(iv)	**Explain how noise suppression is done during installation of PLC.**		**04**
Ans.	**Noise Suppression during PLC installation:** Noise suppression is an important parameter in PLC installation because noise is nothing but unwanted signal which produce undesirable effect. To reduce the noise following points must be considered: • High voltage power cables and low voltage control cables must be routed separately. • Grounding of PLC and other devices must be proper with low resistance path. • Large voltage and high frequency devices must be placed away from PLC. • If possible fiber optic cables can be used which reduces noise significantly. • Noise signal immediately affect the analog I/O signal so analog devices should keep away from noise generating devices. **OR** **Note: Any other relevant points should be considered**	**01 marks for each point** **(04 points)**	
b)	**Attempt any ONE of the following**		**06**
(i)	**List 3 input and 3 outputs devices with their symbols, which can be used with PLC.**		**06**
Ans.	Input Devices:		

	1) Normally open push button  2) Normally closed push button  3) Normally closed limit switch  Output Devices: 1) Indicator lamp  2) Horn  3) Solenoid  **Note: Other relevant devices should be considered**	**01 mark for each input device** **(03 I/p devices)** **01 mark for each output device** **(03 O/p devices)**	
(ii)	**Explain analog output module with the help of block diagram.**		**06**
Ans.	 Block diagram of Analog output module	**02 marks for diagram**	

	Explanation:- • CPU sends data to output module through different blocks. Optical isolation blocks isolate. • CPU circuit from high voltage o/p devices. • Isolation section of the input ckt. Is usually made up of an optical isolator, or opt coupler. In a 120VAC input module, isolation separates the high voltage, 120VAC input signal from the CPUs low voltage control logic. • DC signal from the opto coupler are used by the logic section to pass the input signal to the module's input address LED and the CPU and then on to the input status file. • This module accepts 16 bit status word, convert it into analog value using DAC. • Analog signals are 0 to 10Vdc, -10Vdc to +10Vdc, 0 to 5Vdc 0 to 20mA, -20 to +20mA,4mA to 20mA.etc. • These modules are selected to send output either a varying current or voltage signal, each represent particular operation.	**02 marks for explanation**	
5	**Attempt any TWO of the following**		**16**
a)	**(i) Draw block diagram of DC output module.** **(ii) Draw wiring diagram to connect AC load to PLC and specify which type of output module can be used.**		**08**
Ans.	**(i) Block diagram of DC output module:**  **OR** **Note: Any other relevant block diagram should be considered.** **(ii) Wiring diagram to connect AC load to PLC and specify which type of output module can be used.**	**04 marks for labeled block diagram** **03 marks for wiring diagram**	

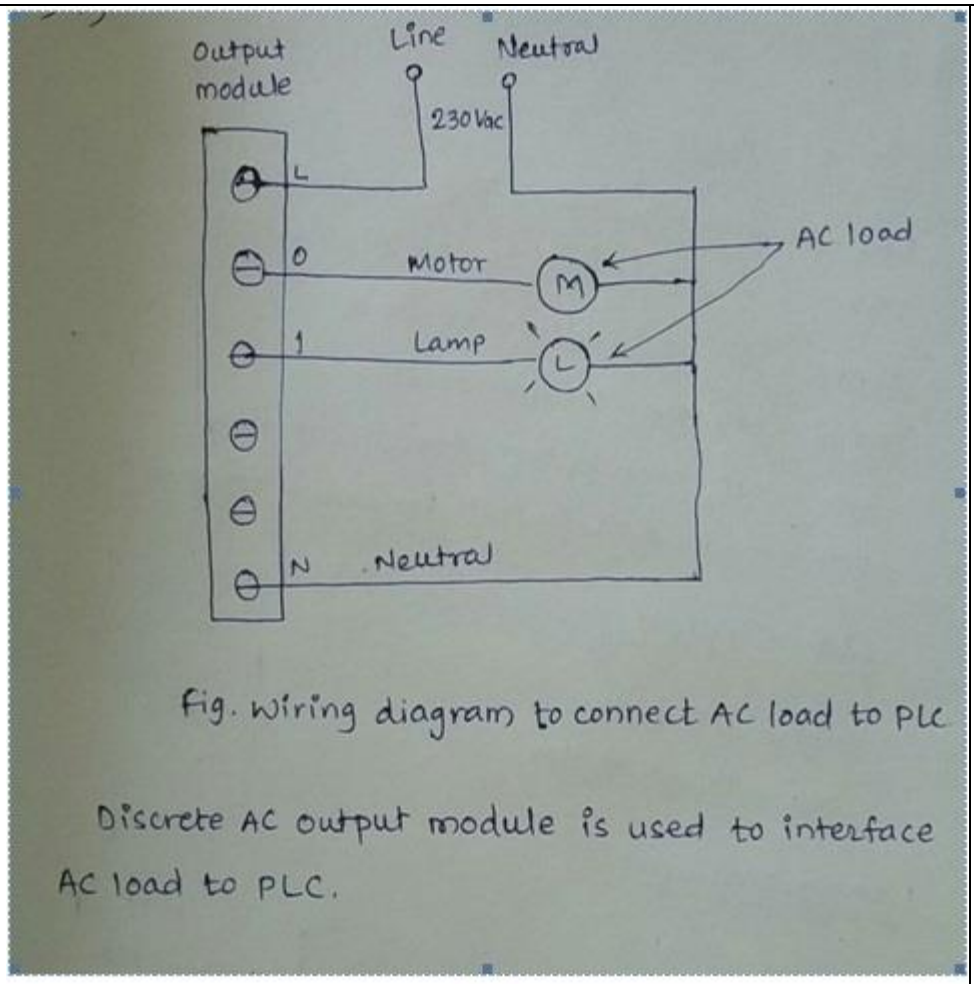


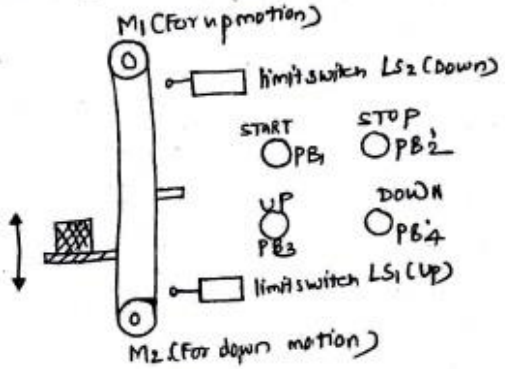
fig. Wiring diagram to connect AC load to PLC

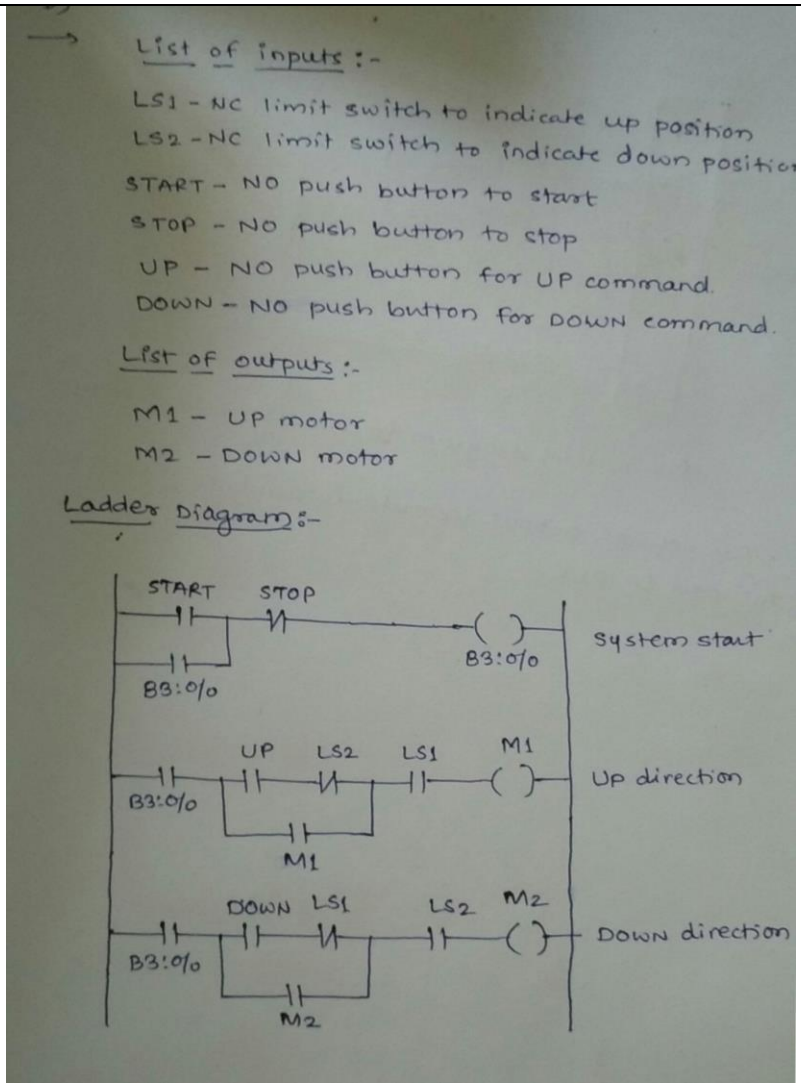
Discrete AC output module is used to interface AC load to PLC.

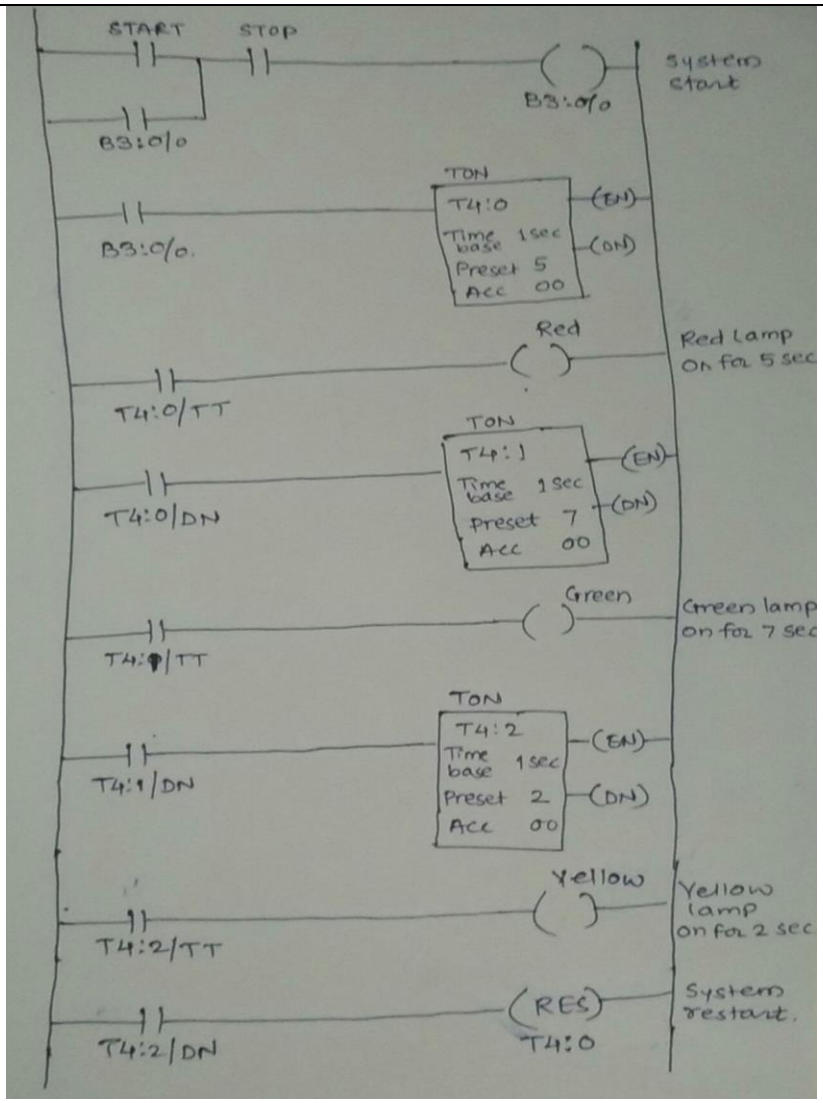
01 mark for name of output module

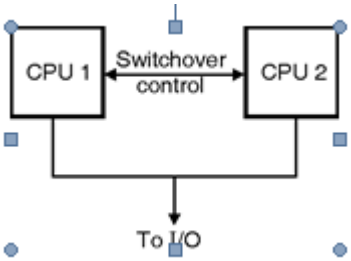
OR

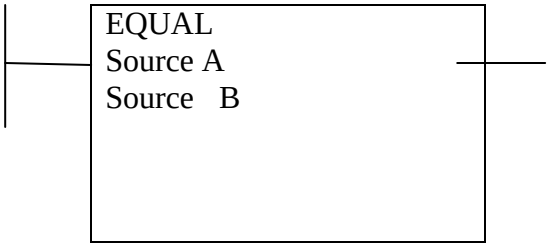
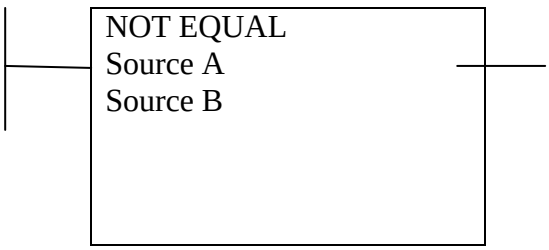
Note: Any other relevant wiring diagram should be considered.

b)	b) The elevator system shown in diagram employs platform to move objects up and down. M1 and M2 are motor to drive platform UP and DOWN respectively write ladder program for following conditions: (i) When start push button is pushed process starts and when stop push button is pressed process stops? (ii) When UP push button is pressed, platform carries something to UP position till L.S1 senses UP position. (iii) When DOWN push button is pressed, platform carries something to DOWN position till LS2 senses down position.  LS_1 = NC limit switch to indicate UP position LS_2 = NC limit switch to indicate DOWN position START = NO push button for start STOP = NO push button for stop UP = NO push button for UP command DOWN = NO push button for DOWN command **Fig. No. 2**		**08**

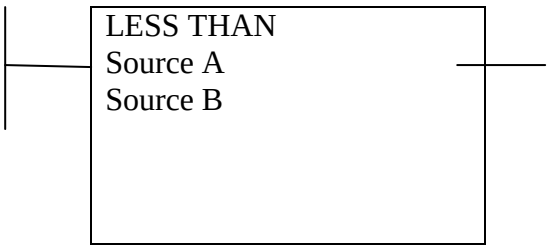
Ans.	→ List of inputs :- LS1 - NC limit switch to indicate up position LS2 - NC limit switch to indicate down position START - NO push button to start STOP - NO push button to stop UP - NO push button for UP command. DOWN - NO push button for DOWN command. List of outputs :- M1 - UP motor M2 - DOWN motor Ladder Diagram :-  **OR** **Note: Any other relevant ladder diagram should be considered.**	**08 marks for detailed ladder diagram**	
c)	**Write ladder program for traffic light control system for following conditions:** **(i) When start push button is pressed, RED light is ON for 5 sec?** **(ii) After 5 sec. RED light goes OFF and GREEN light should become ON for next 7 sec.** **(iii) After 7 sec. green light goes OFF and yellow light should become ON for next 2 sec.** **(iv) After 2 sec. Yellow light goes OFF and again RED light should become ON and cycle should repeat till STOP push button is pressed.**		**08**

Ans.	 **OR** **Note: Any other relevant ladder diagram should be considered.**	**08 marks for detailed ladder diagram**	
6	**Attempt any FOUR of the following**		**16**
a)	**Explain the term redundancy with respect to PLC.**		**04**
Ans.	**Redundancy :** • Redundancy means extra system components or mechanisms added to decrease the chance of total system failure. • Different types of redundancy are available in PLC like redundancy for a CPU module, power module, bases and communication module is available. • CPU redundancy system is composed of separate bases for ideal redundancy structure. • In case an error occurs in an active CPU module, a backup	**04 marks for explanation**	

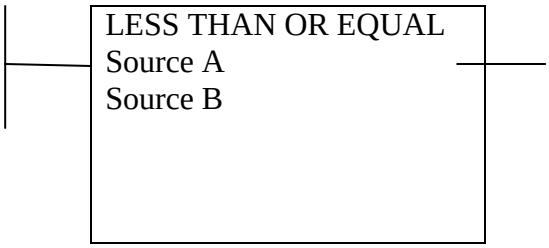
	module is automatically converted to active one for continuous operation. • In these cases two processors can be tied into one I/O system and some means is provided that switches control from the failure CPU to the backup when a failure CPU to the backup when a failure occurs as shown in Fig.  		
b)	**Explain DOWN counter instruction format of PLC.**		**04**
Ans.	**DOWN counter (CTD):** The CTD is a retentive output instruction that counts false to true rung transitions and accumulated value is decremented by one count. The accumulated counts are retained when the rung condition again becomes false. The accumulated count is retained until cleared by a reset (RES) instruction that has the same address as the counter reset. The DOWN counter instruction format is shown in fig. CTD Count down Counter Preset Accumulator When the reset instruction is used for a counter, the ACC value is '0' and DN bit is reset, CU bit is reset, and CD bit is reset.	**02 marks for explanation** **02 marks for format**	

c)	**State PLC maintenance guidelines.**		**04**
Ans.	Guidelines for maintenance of PLC • Periodically check the tightness of I/O Module terminal Screws . They can became loose over period • Periodically check for corrosion of connecting terminals moisture & corrosion atmospheres can cause poor electrical connections • Make sure that components are free of dust • Stock commonly needed spare parts • Keep duplicate record of operating programs being used • Replace the PLC batteries used for backup in time • Have a written check list , control list for each PLC Keep additional check list for each PLC with records of what , Who, when should be kept. **OR** **Note: Any other relevant points should be considered.**	**01 mark for each point (max 04 points)**	
d)	**List four Compare instructions and also draw their formats.**		**04**
Ans.	**Compare Instructions: (Any four)** **i) 'EQUAL' or 'EQU' Instruction:**  **ii) 'NOT EQUAL' or 'NEQ' Instruction:**  	**01 Mark for each instruction with format (Maximum 04 instructions)**	

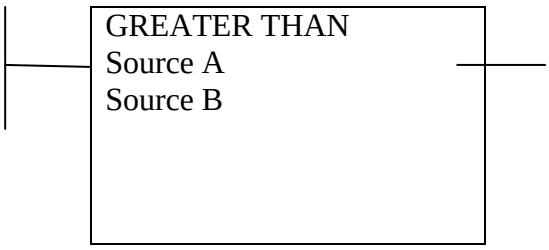
iii) 'LESS THAN' or 'LES' Instruction:



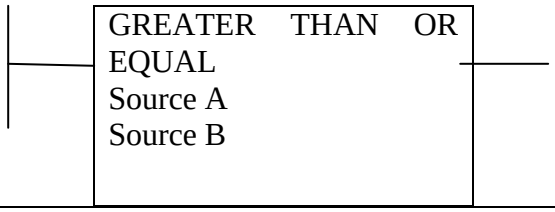
iv) 'LESS THAN OR EQUAL' or 'LEQ' Instruction:



v) 'GREATER THAN' or 'GRT' Instruction:



vi) 'GREATER THAN OR EQUAL' or 'GRQ' Instruction:



e)	**Explain how troubleshooting of input and output module is done in PLC.**		**04**

Ans.	**Troubleshooting in PLC:** The troubleshooting of PLC system can be done in following manner. Input devices e.g. switches can be manipulated to give the open and closed contact conditions and the corresponding LED on the input module observed. It should be illuminated when the input is closed and not when it is open. Failure of LED to illuminate could be, because the input device is not correctly operating/ there is incorrect wiring connection to the input module/the input device is not correctly powered or LED or input module is faulty. For output devices that can be safely started, Push button might have been installed so that each output can be tested. Another method that can be used to test inputs and outputs is termed as **forcing.** This involves software, rather than mechanical switching ON or OFF, being used with instructions from the programming panel to turn ON or OFF inputs/outputs. In order to do this, a PLC has to be switched into the **forcing** or **monitor** mode by pressing a key marked FORCE or selecting that mode on a screen display. A portion of the program may operate properly in the FORCE mode but not during actual operation. For example input IN 0045 may operate correctly in the FORCE mode but not in actual operation. This would indicate that the input, IN0045, is malfunctioning because of internal or external reasons.	**04 marks**	