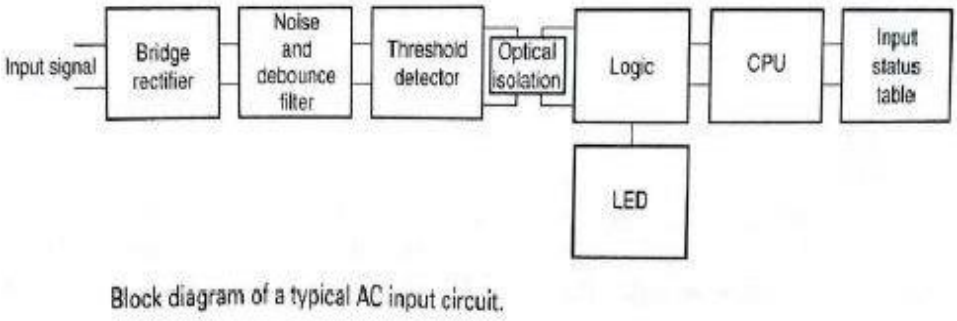
Important Instructions to examiners:

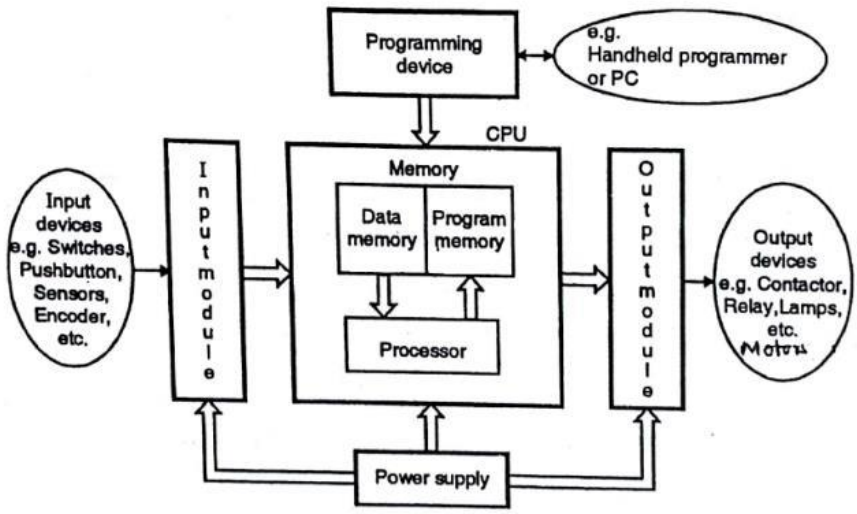
1) The answers should be examined by keywords and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling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

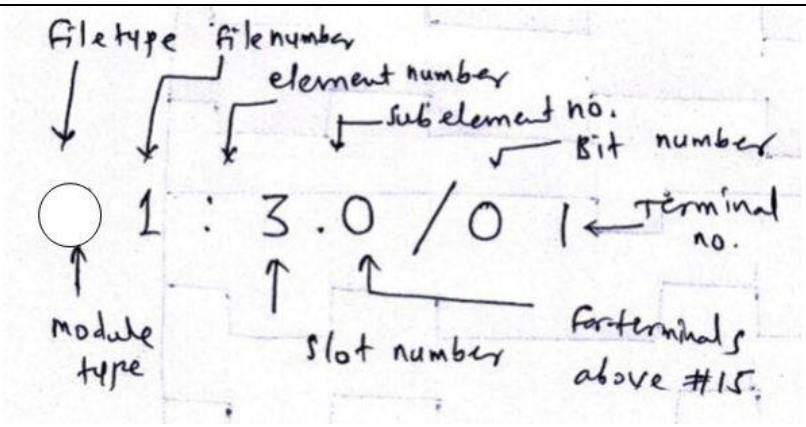
Q. No	Question & its answer	Remark	Total marks
01 A)	**Attempt any THREE**		12
a)	**State any three different tools used for Automation.**	04	
Ans.	**1) SCADA: Supervisory control and Data acquisition system**. It is basically software, which runs on a central PC and connected to the different field 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 :** i) A distributed control system (DCS) is a control system for a process or plant, wherein control elements are distributed throughout the system. ii) 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 mark for each tool (max. 04 marks)**	

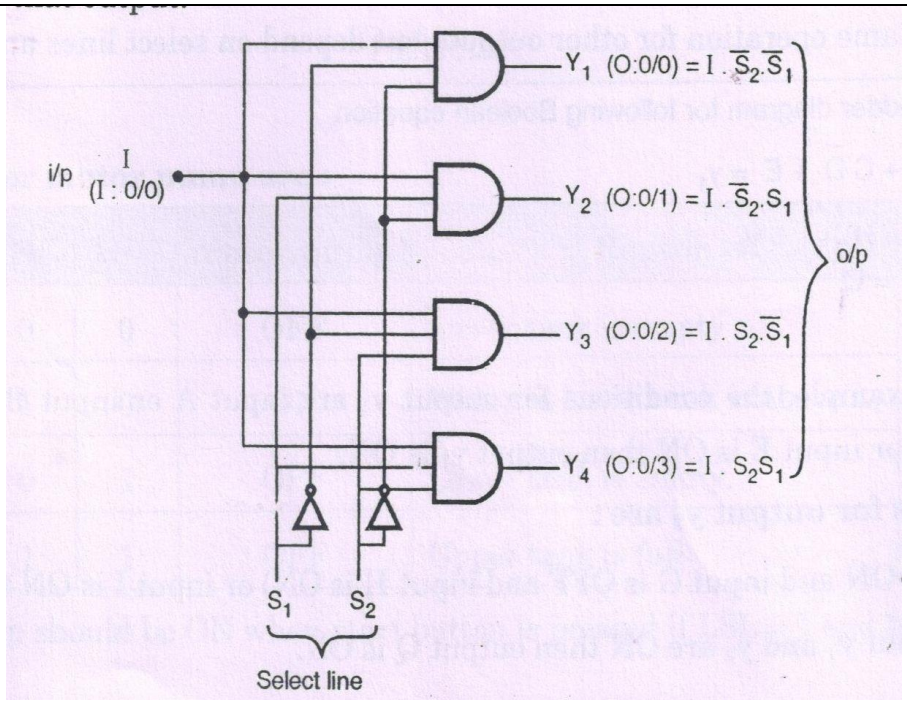
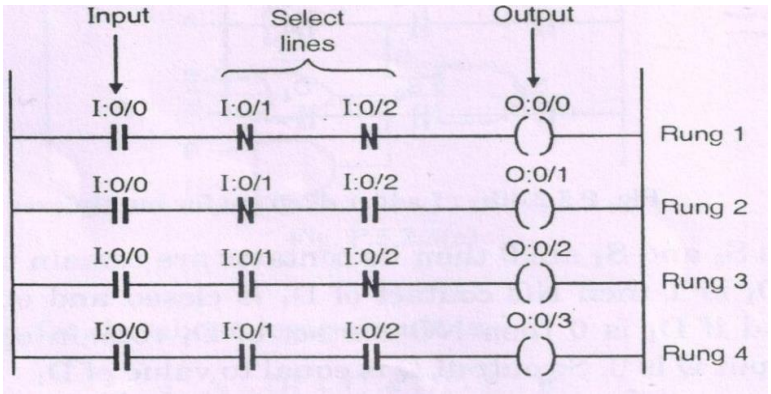
	OR **Any other relevant tools shall be considered**		
b)	**Draw labeled diagram of AC input module**	**04**	
Ans.	 Block diagram of a typical AC input circuit.	**04 mark for diagram**	
c)	**Differentiate Relay based system & PLC control system (any four points)**	**04**	
Ans.		**01 mark for each point (max. 04 marks)**	

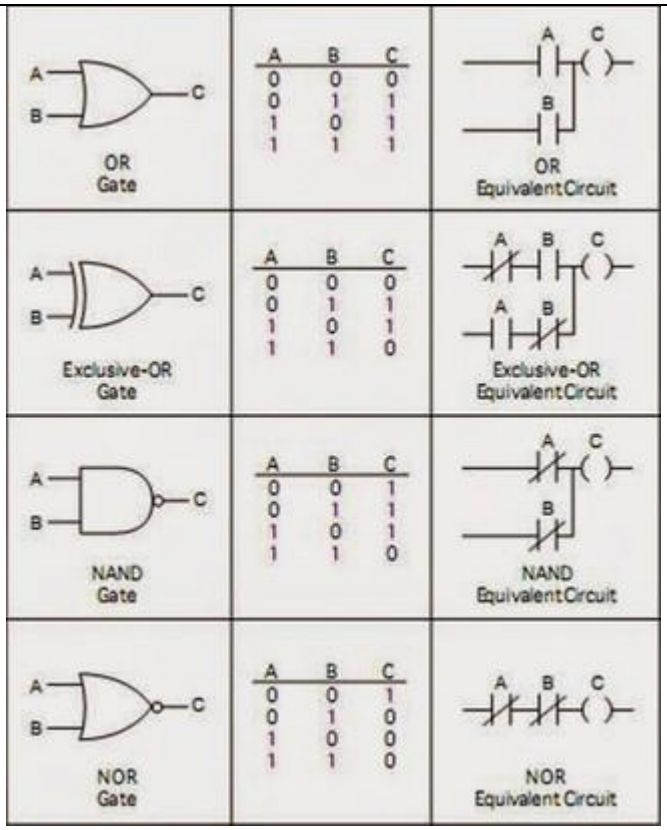
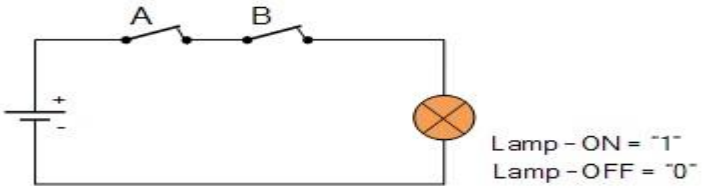
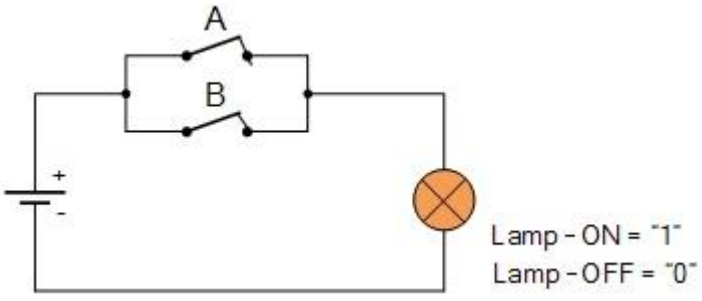
Parameter	**Conventional control**	**PLC-Based control**
Tools used for automation	Hard wiring	Software programs
Space requirements	Requires a large amount of space to house	smaller space is required
Power consumption	Higher power consumption	Lower power consumption
Installation	Installation process is difficult	Installation process is easier
Maintenance	High maintenance is required	Less maintenance is required
Flexibility	Less flexibility for modification	Highly flexible for modification
Reliability	Less Reliability	Highly reliable
Diagnosing problems	Very difficult to diagnose problems	Easy to diagnose problems

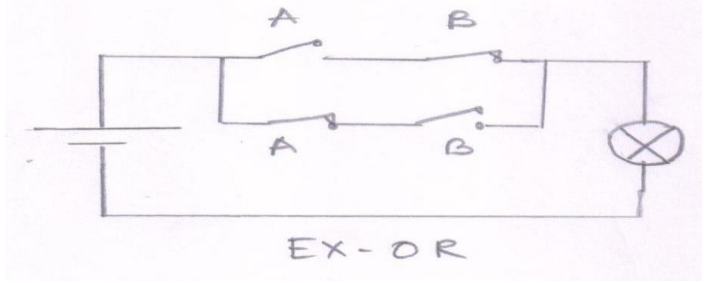
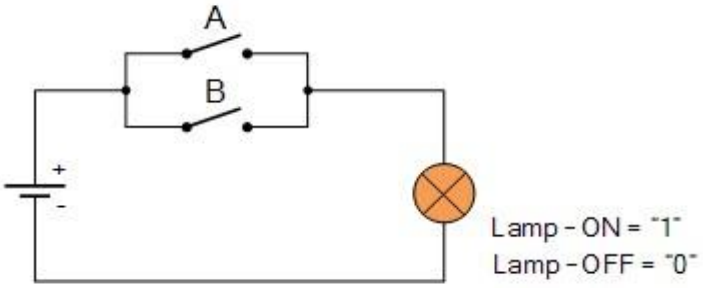
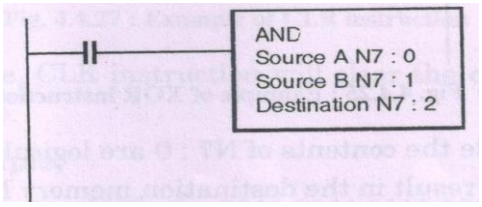
d)	**Draw the functional block diagram of PLC**	**04**	

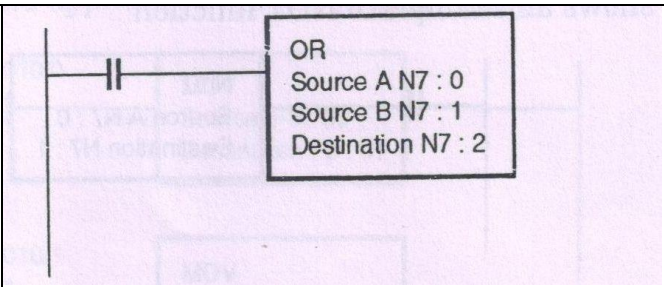
Ans.	 **Block diagram of PLC**	**04 mark for diagram**	
01 B)	**Attempt any ONE**		**06**
a)	**Classify PLC types. Explain each in brief.**	**06**	
Ans.	**Classification of PLC based on type and size:** PLC : - A) Micro PLC (Fixed I/O) It is also called fixed PLC It is micro PLC because of its size It 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. 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	**03 mark for classification** **03 marks for explanation**	
b)	**Explain output devices addressing in PLC with example**	**06**	

Ans.	 **I/O addressing of PLC:** The addressing is necessary to deal with data files for their identification. 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:- O0:2/5	**03 marks diagram** **03 marks explanation**	
02	**Attempt any TWO**		**16**
a)	**Draw ladder diagram 1:4 for demultiplexer**	**08**	

Ans.	 	**04 marks each logic diagram** **04 marks each ladder diagram**	
b)	**Draw the electrical and ladder diagram for following logic gates:** **1. NOR gate** **2. NAND gate** **3. EX-OR gate** **4. OR gate**	**08**	

Ans.	 **OR** **Any other relevant ladder diagrams shall be considered** **(Logic gate & truth table is optional)**  Electrical NOR Gate  Electrical NAND Gate	**01 mark each for ladder diagram (max 04 marks)** **01 mark each for electrical diagram (max 04 marks)**	

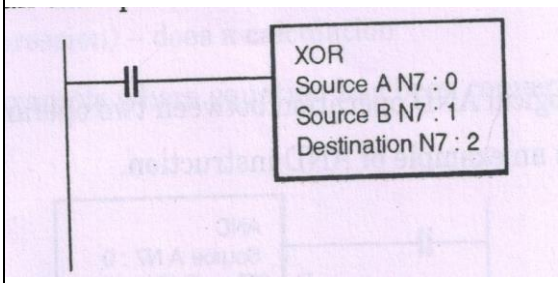
	 Electrical EX-OR Gate  Electrical OR Gate **OR** **Any other relevant electrical diagrams shall be considered**		
c)	**List any four logical instructions of PLC. Write ladder diagram for** **$Y=\overline{\sqrt{(A.B)}}+C$**	**08**	
Ans.	1. AND instruction: It performs the logical AND operation between 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.	**01 mark each for logical instruction (max 04 marks)**	



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

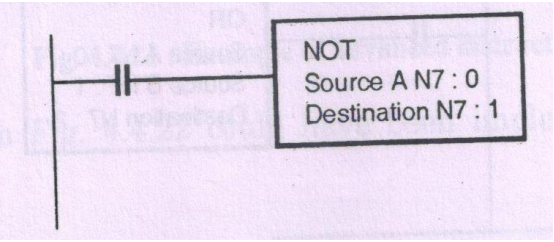


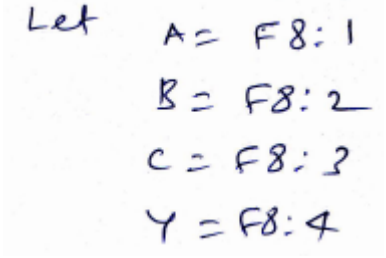
4. NOT instruction:

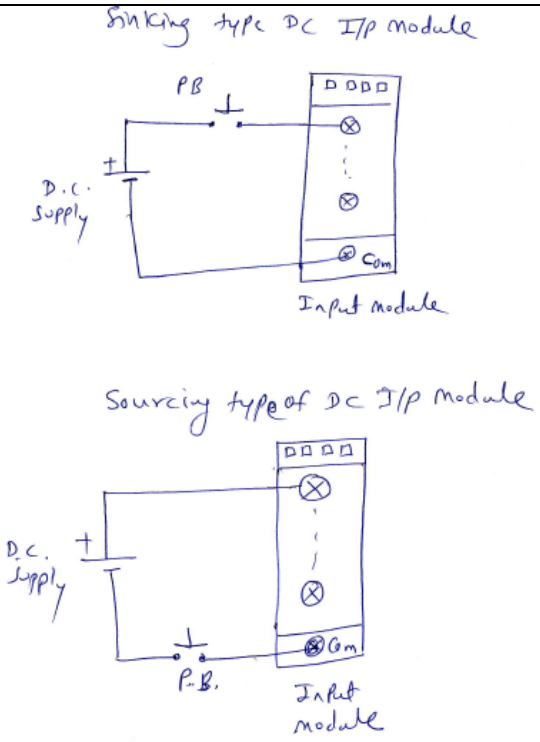
It has single source and perform logical NOT operation and store result in destination memory.

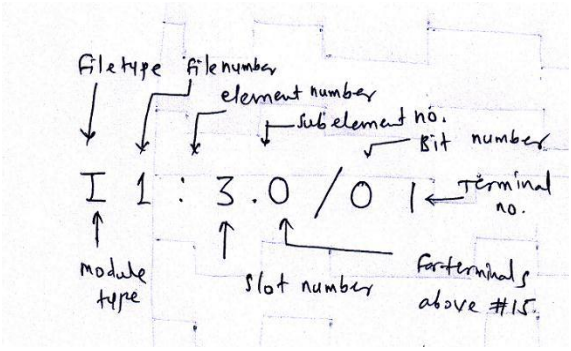
Output is complement of input.

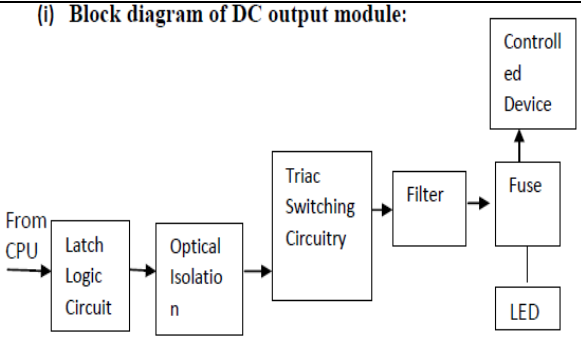
NOT instruction reverses all of the bits in the source word.

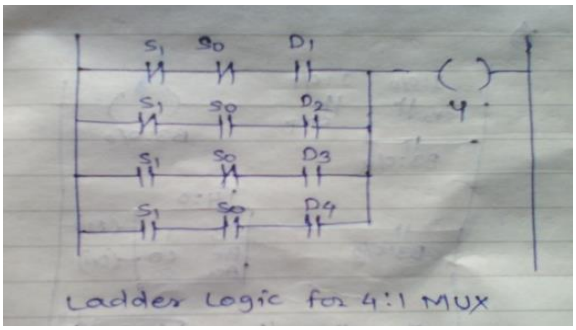
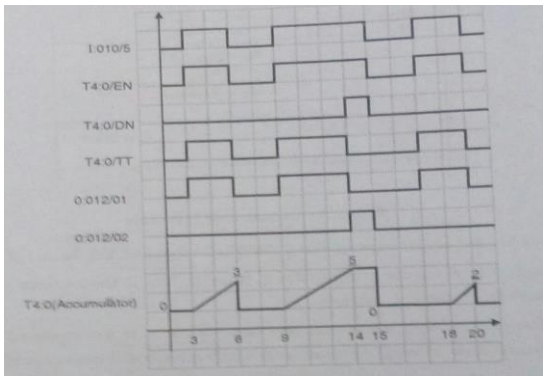


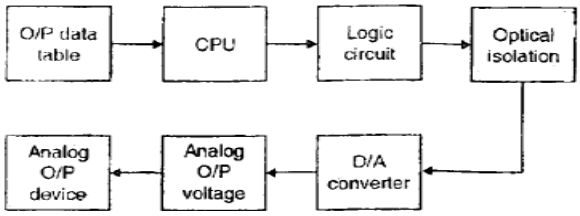
	  **OR** **Any other relevant ladder diagrams shall be considered**	**04 marks ladder diagram**	
03	**Attempt any FOUR**		**16**
a)	**Draw the sinking type and souring type DC input module**	**04**	

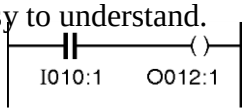
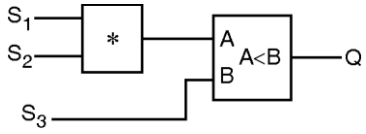
Ans.		**02 marks for sinking type diagram** **02 marks for sourcing type diagram**	
b)	**State the following with respect to PLC installation** **i) Noise Supression techniques** **ii) Grounding requirement**	**04**	
Ans.	**i) Noise Suppression during PLC installation:** Noise suppression is an important 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** **Any other relevant points should be considered** **ii) Grounding requirement:-** Proper grounding is an important safety measure in all electrical	**02 marks**	

	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 your application. The following grounding practices will help reduce electrical noise interference:	**02 marks**	
c)	**What are the addressing modes used in PLC programming? Illustrate with example**	**04**	
Ans.	Addressing modes:- Direct and indirect addressing. **I/O addressing of PLC:** The addressing is necessary to deal with data files for their identification.It is identified by a letter called an identifier and a file number. The basic addressing elements nclude,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.  **OR** **Any other relevant addressing modes with example shall be considered.**	**04 marks**	
d)	**Explain criterion for I/O module selection**	**04**	
Ans.	Criteria's for selection of I/O module:	**04 marks**	

	• Number of analog and digital inputs • Numbers of analog and digital outputs • Type of isolation in I/O module • Sourcing and sinking type of I/O terminals • DC voltage and current ratings for discrete i/p modules • DC voltage and current ratings for discrete o/p modules • Resolution of analog i/p module • Resolution of analog o/p module • Power supply voltage • Type of I/O signals –temperature, pressure, speed control etc **OR** **Any other relevant four points shall be considered**		
e)	**Draw block diagram of DC O/P module**	**04**	
Ans.	(i) Block diagram of DC output module:  **OR** **Any other relevant diagram shall be considered**	**04 marks for diagram**	
04 A)	**Attempt any THREE**		**12**
a)	**What are the different redundancy modules used in PLC**	**04**	
Ans.	Redundancy modules:- • Power supply • CPU • Positioning module • Timer/counter module • Communication and peripheral module • Servo control module	**04 marks**	
b)	**Draw the ladder diagram for 4:1 line multiplexer**	**04**	

Ans.	Boolean equation: $Y=\overline{S0}\,\overline{S1}D0+S0\overline{S1}D1+\overline{S0}S1D2+S0S1D3$ Ladder diagram for 4:1 MUX  **(Logic diagram is optional)**	**01 mark** **03 marks for ladder diagram**	
c)	**Draw the timing diagram of TON timer showing status of DN bit, TT bit,& EN bit.**	**04**	
Ans.	Timing diagram:-  **OR** **Any other relevant timing diagram shall be considered**	**04 marks**	
d)	**Explain need of automation.**	**04**	
Ans.	Need of Automation in process : • To fulfill the demand of product at right time. • To reduce the human errors and involvement of human being in the process.	**01 mark for each**	

	• For better productivity. • For better control of process. • For better quality . • For reducing man power. • For reducing cost of product. **OR** **Any other relevant points shall be considered**		
04 B)	**Attempt any ONE**		**06**
a)	**Classify the following instructions into input and output instructions with respect to PLC**	**06**	
Ans.	Input Instructions:- 3) -| |- , 6) –(GET)- , 7)–(PUT)- Output instructions:- 1)CTU, 2)CTD 4) -( )- , 5) -(L)-	**03 marks** **03 marks**	
b)	**Draw analog output module. State the functions of each block.**	**06**	
Ans.	Diagram of Analog output module  **Description:** Analog output modules accept 16 bit output status word, which they convert to an analog value through a digital to analog converter. The converter is a part of the electronics inside the analog output module. Typical analog signals are 0 to 10 V DC, -10 to 10 V DC, 0 to 5 V DC, 1 to 5 V DC, 0 to 20 milliamps, -20 to +20 milliamp or 4 to 20 milliamps. Analog output modules are selected to send out either a varying current or voltage signal. Optical isolator is used to isolate load from cpu for protection purpose. Logic circuit is used to provide required signal value for optical isolation.Output stage is any output device which is actuated. For example An analog output sends a 4 to 20 milliamp signal to variable speed drive. The drive will control the speed of a motor in proportion to the analog signal received from the analog output module	**03 marks for diagram** **03 marks for explanation**	

05	**Attempt any TWO**		**16**
a)	**State different PLC programming languages used. Illustrate with one example.**	**08**	
Ans.	**PLC programming languages:** This standard specifies five languages divided into two parts namely- graphical languages and text-based languages. A) Graphical languages : i) Ladder Logic Diagram (LD) ii) Function Block Diagram (FBD) iii) Sequential Function Chart or Grafcet (SFC) B) Text-based languages : i) Instruction List (IL) ii) Structured Text (ST) **Explanation of PLC programming languages:** i) Ladder logic diagram(LD): It is a type of graphical language having the instructions in graphical symbol format. Ladder program is very similar to electrical wiring diagram, so it is easy to understand.  Fig. Ladder logic diagram ii) Function Block Diagram (FBD): The primary concept behind FBD is data flow in this instructions are composed of operational blocks, Each block has one or more inputs and outputs.  Fig. Simple comparison example iii) Sequential Function Chart or Grafcet (SFC): This language is used for performing simultaneously operations required for controller in complex machine process	**03 marks for list** **05 marks for example and explanation**	

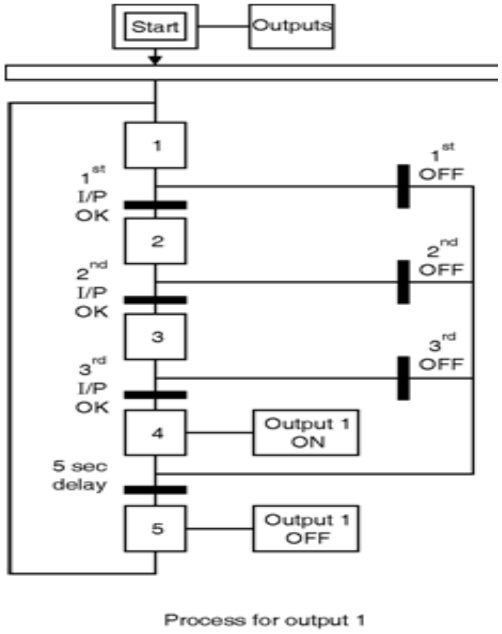


Fig. SFC example

iv) Instruction List (IL):

It is similar to assembly language programming, in this low level computer language like mnemonic codes are used to specify the operation of each rung of ladder diagram.

e.g. simple IL program:

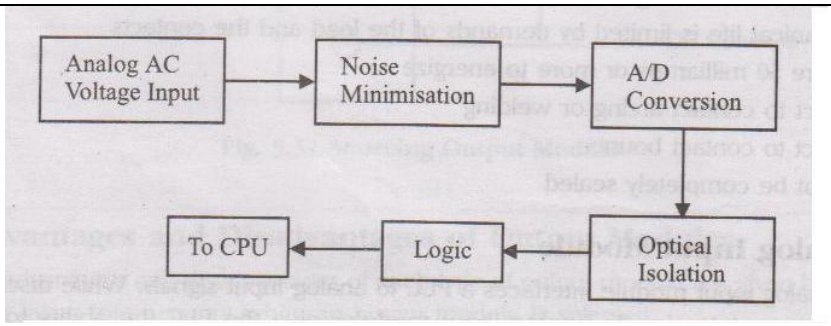
Lable	Instruction		Comment
Start :	LD	$I_{0.0}$	Load input $I_{0.0}$
	AND	$I_{0.1}$	First logically OR inputs $I_{0.1}$ and
	OR	$I_{0.2}$	$I_{0.2}$ and the logically AND with input $I_{0.0}$
	ST	$Q_{0.0}$	Store output $Q_{0.0}$ depending on result.

v) Structured Text (ST):

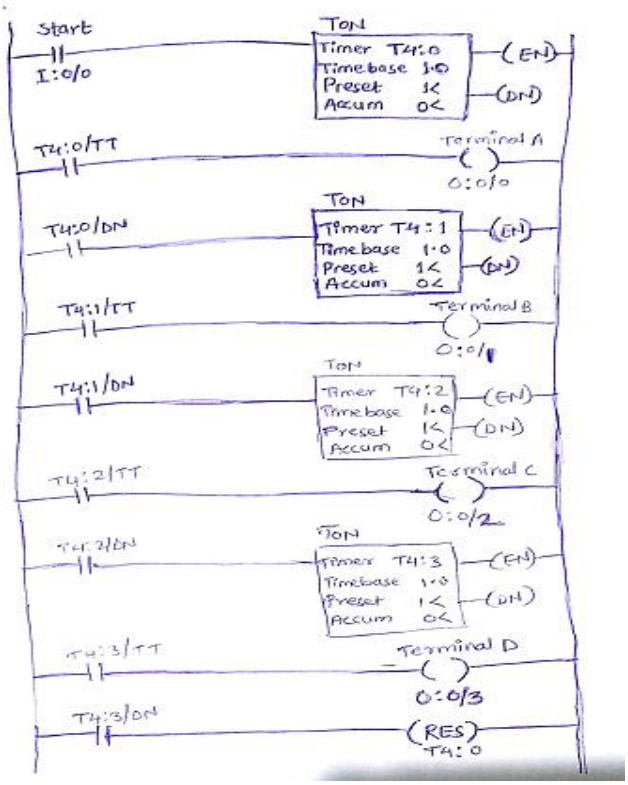
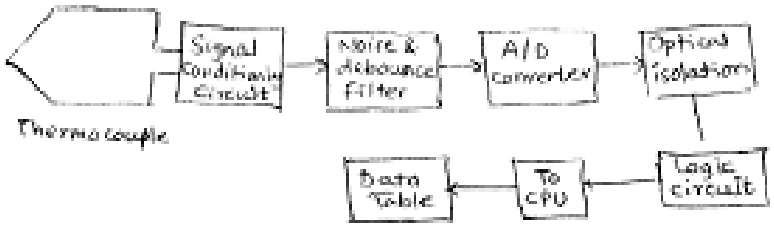
It is a high level computer type language like Basic or C. It is capable to perform calculations on values other than binary.

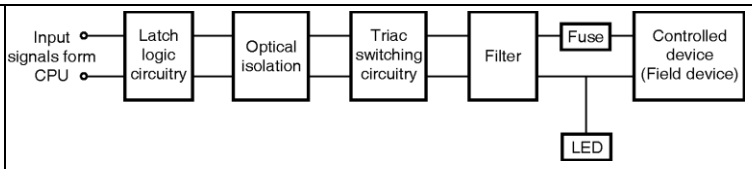
```
PROGRAM main
        VAR
        x : INT ;
        END_VAR
        x : = 0 ;
        REPEAT
        x = x + 1 ;
        UNTIL x > = 20 ;
        END_REPEAT ;
         END_PROGRAM.
```

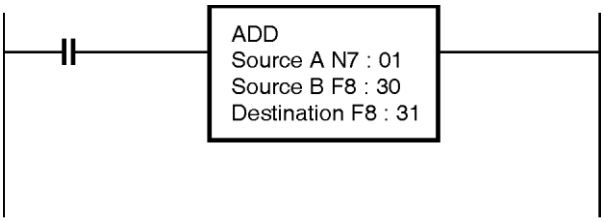
Note: Any other relevant explanation with example of programming languages should be considered.

b)	**Draw block diagram of analog input module. Explain each block in detail.**	**08**	
Ans.	 **Fig. Analog input module** • Fig. Illustrates the block diagram of a single channel analog voltage input module. • An analog input module interface a PLC to analog input signals. It gives the PLC the ability to monitor a continuously changing input signals representing pressure, temperature, flow etc. • The module converts analog input signals to 16 bit binary values for storage in the processor's input status table. • Analog input modules are selected to accept either a current a voltage input signal. The input signal levels are usually 0 to 10 V_{DC}, – 10 to + 10 V_{DC}, 0 to 5 V_{DC}, 1 to 5 V_{DC} or 0-20 mA, – 20 to +20 mA or 4 – 20 mA. • When an analog signal reaches an input module, it is rich in different noise signals. The signal is made free from noise signal using noise and de-bounce filter circuit and applied to	**04 marks for block diagram** **04 marks for explanation**	

	analog to digital converter. • A/D converter which converts the analog input voltage to a digital signal. The digitized signal is then passed through optical isolation circuit to a logic circuit. • The logic section allows digitized signal to the CPU and on to the data table for storage.		
c)	**Draw ladder diagram for stepper motor control in clockwise direction.**	**08**	
Ans.	Stepper motor has four coils (coil A, coil B, coil C and coil D). Following are the sequences of the coil for clockwise rotation of the stepper motor. **Clock Wise Motion:** Step | Terminal A | Terminal B | Terminal A' | Terminal B' 1 | 1 | 0 | 0 | 0 2 | 0 | 1 | 0 | 0 3 | 0 | 0 | 1 | 0 4 | 0 | 0 | 0 | 1 1 | 1 | 0 | 0 | 0 Ladder Diagram for clockwise rotation: List of I/Os with addresses: Start button – I:0/0 Coil terminal A- O:0/0 Coil terminal B- O:0/1 Coil terminal C- O:0/2 Coil terminal D- O:0/3 ON delay timers – T4:0, T4:1, T4:2, T4:3	**02 marks for sequence and list of I/Os with address**	

	 **OR** **(Any other ladder logic diagram should be considered)**	**06 marks for ladder diagram**	
06	**Attempt any FOUR**		**16**
a)	**Draw the block diagram of thermocouple module.**	**04**	
Ans.	 **Fig. Block diagram of Thermocouple module** **OR** **Any other relevant diagram should also consider**	**04 marks**	
b)	**Draw block diagram of AC O/P module. Explain it.**	**04**	
Ans.	**AC output module:**	**02 marks for block**	

	 **Fig. Block diagram of AC output module** **Latch logic circuit and optical isolation circuit:** i) If the status of output terminal is one and if CPU sends low voltage signal (12-18 V DC) to the latching circuit. ii) Latching circuit will latch that logic signal as a ON state and then send it to the optical isolation circuitry. iii)Same operation is performed for status is zero. iv)Optical isolation circuit will isolate low voltage signal of CPU and high voltage operating field devices. **Switching and filtering circuitry:** i)In this block, TRIAC is a solid state switching device used to provide high voltage operating signal to output field devices. ii) TRIACs are switched ON or OFF by the signal from optical isolation circuit. iii) AC signals switched by TRIAC are filtered to a safe level by filtering circuitry. iv)To indicate the status of the output LED is provided on output module v)In some output module circuit, fuse is provided to protect the circuit from drawing higher current. **Controlled device(Load):** i)Controlled device are the field output devices may operate from different voltages. ii) When the status of output is one in output data table then controlled device turns ON and when status is zero, then device turns OFF.	**diagram** **02 marks for explanation**	
c)	**Explain any four maintenance guidelines for PLC.**	**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 porr electrical connections • Make sure that components are free of dust • Stock commonly needed spare parts • Keep duplicate record of operating programs being used	**01 mark for each point (max 04 marks)**	

	• Replace the PLC batteries used for backup in time • Have a written check list , control list for each PLC • Keep additional maintenance check list for each PLC with records of what , who , when . **OR** **(Any other relevant points should be considered)**		
d)	**List arithmetic instruction of PLC. Explain any one instruction with example.**	**04**	
Ans.	**Arithmetic instructions:** 1) Addition (ADD) 2) Subtraction (SUB) 3) Division (DIV) 4) Multiplication (MUL) 5) Negate (NEG) **Addition (ADD) instruction:** • ADD instruction will retrieve values from source A and source B convert both valves to the type of destination address, then value of source A is added to the value of source B and store the result in destination address. • Fig. shows the function block of ADD instruction.  • In above Fig. source A is integer value, source B is floating point number and type of destination address is also floating point number. • Therefore, ADD instruction first convert values of both the sources to floating point number. • Then add both the values and result is floating point number which stored in the destination address. • For example, if value of source A is 10 i.e. N7 : 01 = 10 and value of source B is 25.5 i.e.	**02 marks for list of instructions** **02 marks for any one instruction**	

	F8 : 30 = 25.5 then result is, F8 : 31 = 35.5 **OR** **(Any other one arithmetic instruction explanation should be considered)**		
e)	**Illustrate fault detection techniques for LED status of input and output module.**	**04**	
Ans.	• PLC manufacturer usually provides LED status indicator for every input and output terminals. • There is a LED for power indication. It will be illuminated when power is ON otherwise it is off. • When supply is ON but power indicator LED is OFF, it means there is a problem in power supply. • Mode indicator LEDs are also on PLC which indicates the program or run mode of the PLC. • For input status LED when there is a input high signal at input terminal then this LED is ON it indicates that valid input is arrived. For low input signal this LED turns OFF. • If the output LED is on and the output devices is not on, test for power at the suspected output terminals. If there is a power at output terminal, the PLC is functioning. • If power is not present on PLC output terminal, the PLC has failed and must be replaced. • Next test for power at nonfunctioning output device. If there is a power at the output terminal then the device is faulty and should be fixed or replaced.	**04 marks for explanation**	