- A pressure sensor X1 will be activated HIGH (ON).
- Y2 will be reset LOW (OFF)
- Timer T1 will be activated HIGH (ON) for 60 sec.
- The agitator Y3 will be HIGH (ON) for 60 sec, which is the set value of Timer T1.
4. After 60 sec, the agitator Y3 will be Low (OFF) and Y4 (the ready – made coffee outlet) will be HIGH (ON) and latched and the ready –made coffee will be pouring out from the Y4 outlet.
5. When the coffee is poured into the paper cup completely, X1 will be LOW (OFF) and Y4 will be reset LOW (OFF) the ready-made coffee outlet will be closed.

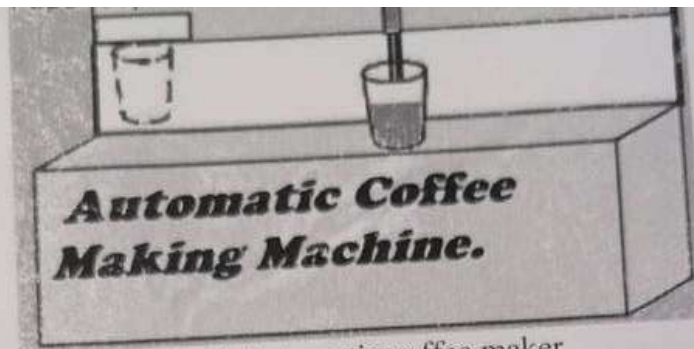Draw the PLC ladder diagram for the infusing container system above.
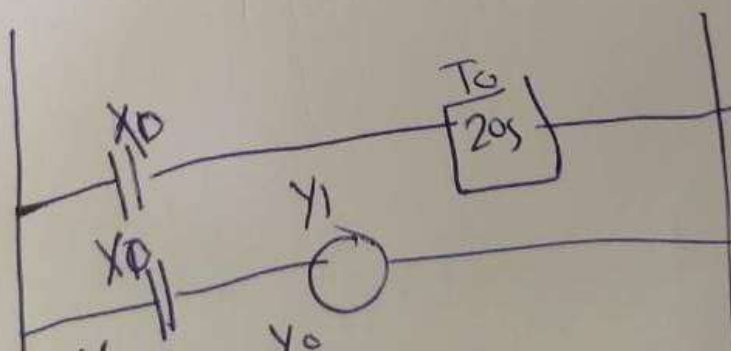
Fig.1 Automatic coffee maker

1. When a coin is inserted, X0 is HIGH (ON) and the following outputs will be activated at the same time:
   - A timer T0 will be activated for 2 sec
   - Y0 (paper cup outlet) will be HIGH (ON) and latched (a paper cup will be sent out)
   - Y1 (coffee powder outlet) will be HIGH (ON) and latched (a certain amount of coffee will be poured into the container).
   - Y0 and Y1 will be HIGH (ON) for 2 sec, which is the set value of the timer T0.

2. After 2 sec, Y2 (hot water outlet) will be activated HIGH (ON), and the hot water will be poured in the container. At the same time, Y0 and Y1 will be closed LOW (OFF).

3. When the liquid in the container reaches a certain amount of pressure:

Q4) (10 marks) Given the controller equation:

$$A = \bar{B} \cdot \overline{(C \cdot (\bar{D} + E + \bar{C}) + \bar{F} \cdot C)}$$

A) Draw the logic combinational circuit for A..

B) Draw the ladder diagram for the combinational logic circuit in part A.

C) Simplify the expression A.

D) Draw the logic circuit for the simplified expression A.

E) Draw the ladder diagram for the simplified expression A.

D) The line efficiency cannot be predicted by just increasing the number of workstations without increasing the handling systems units between stations.

E) The line efficiency is related to the other factors than the number of workstations.

(5) If a storage buffer is nearly always empty or nearly always full, this indicates a problem area that is:

A) A system reliability.

B) Processing technology – cutting tool technology, speeds and feeds.

C) Line balancing.

D) B + C

E) All of the above

(6) One of the following sentences is incorrect about multi-station assembly machine or line:

A) Faster cycle rate

B) More operations possible

C) More complex assembly design is possible to be handled.

D) Suited to robotic assembly

E) C + D

(7) The group technology (GT) is:

A) It is a manufacturing philosophy.

B) Similarities among parts permit them to be classified into group technology.

C) Exploits the part similarities by utilizing similar processes and tooling to produce them

D) A + B

E) A + C

(8) Cellular manufacturing is:

A) Implemented by manual or automated methods.

B) Organizing the production facilities into manufacturing cells that specialize in producti of certain part families.

C) Application of group technology into manufacturing workstations, workstations do the same processes are grouped together.

D) A + B

E) All of the above

(9) Cellular manufacturing are most applicable when:

A) The plant uses batch production and process type layout.

B) The plant uses mixed production and process type layout.

C) The parts can be grouped into part families.

D) A + C

E) B + C

(10) The main difference between cellular and flexible manufacturing is:

A) Flexible manufacturing is a highly automatic cellular manufacturing system.

B) Flexible manufacturing can produce several part families, while cellular manu can only produce a part family or a limited range of part families.

C) Cellular manufacturing is a special case of process type layout, while flexibl manufacturing is based on a hybrid process – product layout.

Section			

Q1 (30 marks) Choose the correct answer for the following multiple-choice questions:

(1) An automated production line is:
A) Consisting of multiple workstations that are automated.
B) A variable routing manufacturing system.
C) Is including a work handling system that transfers parts from one station to the next.
D) A + C
E) All of the above

(2) A storage buffer is:
A) A location in a production line where parts can be stored to increase cycle time.
B) A location in a production line where parts can be collected to provide a bank of parts to supply the line
C) A location in a production line where parts can be temporarily stored to reduce the effect of station breakdowns
D) A + B
E) B+ C

(3) The three basic control functions that must be accomplished to operate an automated production line:
A) Self–diagnosis in order to safely and adequately prepare any faults in the workstations or handling system.
B) Sequence control to coordinate the sequence of actions of the transfer system and associated workstations
C) Safety monitoring and quality control
D) B + C
E) All of the above

4) As the number of workstation on an automated production line increases:
A) The line efficiency increases as the number of stations increases.
B) The line efficiency is unaffected because each additional station needs additional operating costs and maintenance, so in overall efficiency is unaffected.
C) The line efficiency decreases because each additional station increases the probability a line stop.

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D) A flexible manufacturing cell has 2 or 3 stations, while a flexible manufacturing system has 4 or more stations.

E) A + D

(11) The main difference between a dedicated FMS and a random-order FMS is:
A) A dedicated FMS is designed to produce a limited variety of part styles.
B) A random-order FMS is designed to produce a wide variety of part styles.
C) A random-order FMS is more flexible and is more appropriate when the part family is large
D) A + C
E) All of the above.

(12) The main difference between a assembly design and product design is:
A) Assembly design is less complex than product design.
B) Assembly design consumes around 65% of the product design costs.
C) Assembly design consists at least of two parts, while product design consist of single part.
D) A + C
E) B + C

13) The feed rate in the CNC machine is:
A) The distance, which the cutting tool goes during a complete machining job.
B) The velocity at which the cutter is advanced against the workpiece.
C) It is measured in either inch per revolution or millimeters per revolution.
D) A + C
E) B + C

14) The main difference between the CNC machine and the industrial robot is:
A) Industrial robot can be utilized both in manufacturing and in assembly, while CNC machine is a computer-based manufacturing machine.
B) The degree of freedom (DOF) for the industrial robot is more than that of the CNC machine
C) The machine tool envelope for the industrial robot is much larger than the machine tool envelope for the CNC machine.
D) A + C
E) All of the above

5) The difference between fixed routing and variable routing in manufacturing systems consisting of multiple workstations is?
A) Variable routing is suited for high volume production, while fixed routing is suited for small volume production.
B) In fixed routing, work units are transported through a variety of different station sequences. In variable routing, the work units always flow through the same sequence of workstations
C) In fixed routing, the work units always flow through the same sequence of workstations. In variable routing, work units are transported through a variety of different station sequences.
D) Fixed routing is suited for low volume production, while variable routing is suited for hard different product production.
E) C + D

B) It is the most flexible manufacturing system.
C) Economically, the least capital investment of all manufacturing systems
D) For High quantities, it results in the lowest cost per unit produced.
E) It requires the shortest amount of time to implement.

(23) Enablers that are required for unattended operation of mixed model automated production cell are:
A) A parts storage subsystem and a supply of parts to permit continuous operation.
B) Automatic handling of workparts between the storage system and the machine
C) Work unit identification.
D) A + C
E) A + B

(24) A machining center is:
A) Capable of performing multiple machining operations on a work part in one setup.
B) It is CNC machine that is under NC program control.
C) It is an example about the application of multifunction station manned cell.
D) A + B
E) All of the above

(25) The main features of the CNC machining center:
A) Automatic handling and positioning of the work part.
B) Operating unattended for one work cycle.
C) Automatic tool-changer.
D) A + C
E) All of the above.

(26) A machine cluster is:
A) Two or more CNC machines working together.
B) A collection of machines that are loaded and unloaded manually.
C) A collection of two or more machines that are synchronously producing parts or products.
D) B + C
E) A + C

❖ A CNC machining center has a programmed cycle time = 25.0 min for a certain part. The time to unload the finished part and load a starting work unit = 5.0 min.

7) If loading and unloading are done directly onto the machine tool table and no automatic storage capacity exists at the machine, what is the hourly production rate?
A) 8.0 pc/hr
B) 4.0 pc/hr
C) 1.0 pc/hr
D) 2.0 pc/hr
E) Cannot be determined.

(16) A pallet fixture in work transport in a manufacturing system is:
A) A fixturing system that can facilitate the placement of the product to the workstations and the escapement of the product from the workstation.
B) A manual handling system that has many configurations, circular, in-line shuttle and indexing table depends on the capacity required by the manufacturing system.
C) A work holder that is designed to be transported by the material handling system.
D) B + C
E) All of the above

(17) Factors that can be used to classify manufacturing systems are:
A) Product volume and variety
B) Processes that are performed in the manufacturing systems, in terms of their type (assembly or manufacturing) and number.
C) Number of workstations, type (automatic or manual) and their layout.
D) A + C
E) All of the above.

(18) The relation between manning level and automation level in a manufacturing system:
A) Directly correlated to each other.
B) The number of workers required to operate the manufacturing system tends to be reduced as the level of automation increases.
C) Inversely correlated to each other.
D) It is a direct relation, as number of workstations increase the number of workers operating these stations will increase as well.
E) B + C

(19) The cases of part or product variety in manufacturing systems are:
A) Soft variety (batch model) and hard variety (mixed model) and no variety (Unique model)
B) Soft variety (mixed model) and hard variety (batch model) and no variety (single model)
C) Hard variety (mixed model) and soft variety (batch model) and High volume.
D) Hard variety and soft variety.
E) C + D

(20) The capabilities that a manufacturing system must possess in order to be flexible are:
A) The ability to be adaptable in terms of hardware and software
B) To be able to identify different work units.
C) The ability to changeover of operating instructions.
D) The ability to changeover of the physical setup.
E) A + B

(21) Which of the following is incorrect regards the single-station automated cell:
A) A single-station automated cell is a fully-automated machine.
B) It is capable of attended operation for a time - period longer than one machine cycle.
C) A worker is required to be at the machine in order to continuously load and unload parts.
D) B + C
E) A + C

(22) Which of the following is incorrect regards single station manual cell:
A) Technologically, it is the easiest system to install and operate

4 | P a g e
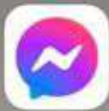
(28) If the machine tool has an automatic pallet changer so that unloading and loading can be accomplished while the machine is cutting another part, and the repositioning time = 30 sec, what is the hourly production rate?
A) 2.35 pc/hr
B) 1.55 pc/hr
C) 3.25 pc/hr
D) 2.45 pc/hr
E) 4.50 pc/hr

(29) If the machine tool has an automatic pallet changer that interfaces with a parts storage unit whose capacity is 12 parts, and the repositioning time = 30 sec, what are the total cycle time?
A) 20.0 min/pc
B) 25.5 min/pc
C) 30.0 min/pc
D) 10.0 min/pc
E) Cannot be determined.

(30) How long does it takes to perform the loading and unloading of the 12 parts by the human worker, and what is the time the machine can operate unattended between parts changes?
A) Time to load/unload = 60 min, UT = 4.1 hr
B) Time to load/unload = 40 min, UT = 4.1 hr
C) Time to load/unload = 60 min, UT = 2.1 hr
D) Time to load/unload = 120 min, UT = 8.2 hr
E) Time to load/unload = 30 min, UT = 2.05 hr

Q2) (6 marks)

A. During calibration, an Iron/Constantan thermocouple is zeroed (set to emit a zero voltage) at 0°C. At 750°C, it emits a voltage of 38.8 mV. A linear output/input relationship exists between 0°C and 750°C. Determine:
(a) The transfer function of the thermocouple and $S = f(s)$ $\qquad$ $S = C + ms$
(b) The temperature corresponding to a voltage output of 29.6 mV.

(a) $S = C + ms$

$38.8 = 0 + 750\,m$

$38.8 = 750\,m$

$\boxed{m = 0.0517}$ $S = 0.0517$

(b) $29.6 = 0.0517s$

$\boxed{S = 572.53\,C°}$

automobile alarm circuit used to detect certain undesirable conditions. A three switches sed to indicate the status of the door by the driver's seat, the ignition, and the headlights ctively. Design the logic circuit with these three switches as inputs so that the alarm wi
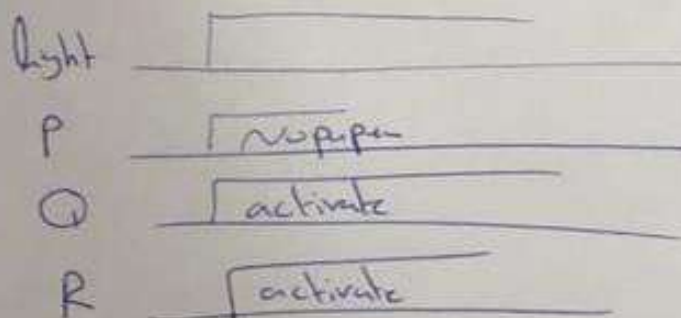
Refer to Figure 1. In a simple copy machine, a stop signal S is to be generated to stop the machine operation and energize an indicator light whenever either of the following conditions exists:
(1) There is no paper in the paper feeder tray; or
(2) The two switches in the paper path are activated, indicating a jam in the paper path.

The presence of paper in the feeder tray is indicated by a HIGH at logic signal P.
Each of the switches produce logic signal (Q and R) that goes HIGH when there is a jam in the paper path.

1) What is the logic function that represents the output signal S for the stated conditions?
2) Design the logic circuit to produce a HIGH at output signal S for the stated conditions.
3) Based on (2) design the ladder diagram for the logic circuit.
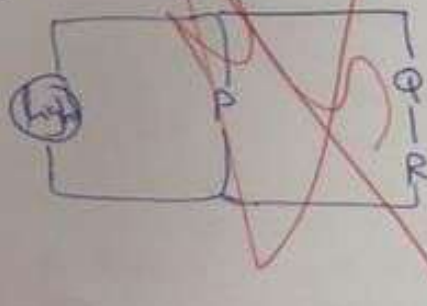4) Based on (2) redesign the logic circuit by only using NAND gates.

L_{saw} + NOT

light _____
P _____ no pipe
Q _____ activate
R _____ activate

$S = QR + \bar{P}$

(2)

(3) Q   R
    ─||──||───── (light)─|
      ─#─
       P

(4) $f_{(a)}$
Q ────┐
      │D── ─1
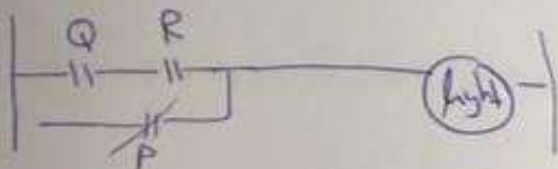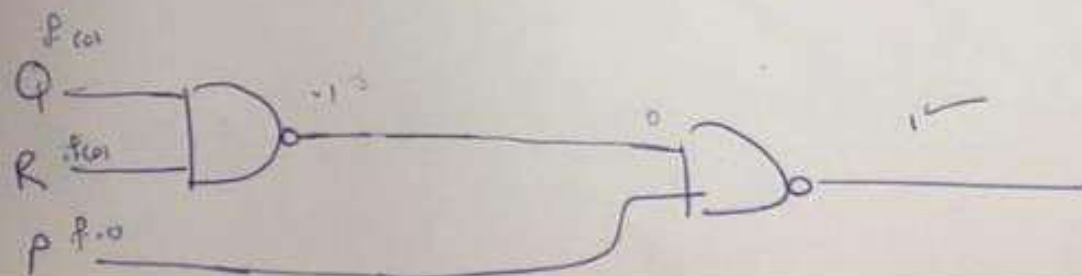R $f_{(a)}$─┘   0
                    D──
P $f_{(a)}$ ────────┘

(A) Electrical power drivers that work as muscles in the control loop.
(B) Devices that convert a controller command signal into a change in a physical parameter.
(C) A transducer that changes one type of physical quantity into some alternative form.
(D) B + C

(7) An example of rotary actuator is:
(A) Hydraulic piston.
(B) AC motor.
(C) Butterfly valve.
(D) Pneumatic solenoid.

(8) The main difference between servomotor and stepper motor is:

(A) Stepper motor can drive lower torque than servomotor.
(B) Open loop control is required to control stepper motor, while closed loop control is required to control servomotor.
(C) Stepper motor is actuated by a digital signal while servomotor is actuated by analogue signal.
(D) B + C
(E) All of the above.

(9) A stepper motor has a step angle of 1.5 degree. Determine number of steps required for the shaft to make 10 revolutions.
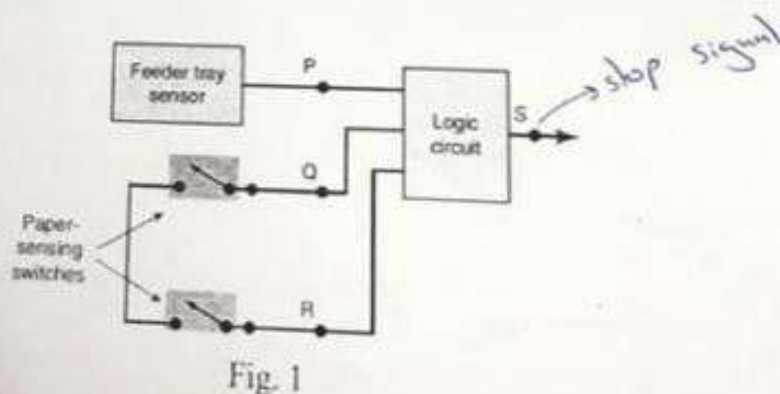(A) Can't be determined.
(B) 1500.
(C) 2400.
(D) 3600.

$$\alpha = \frac{360}{n_s} \quad \rightarrow \quad n_s = \frac{360°}{1.5} \quad \boxed{240}$$

(10) In 9, what pulse frequency is required for the motor to rotate at a speed of 100 rpm (rev/min)?
(A) 1200 Hz.
(B) 200 Hz.
(C) 800 Hz.
(D) 400 Hz.

$$f_p \quad speed = \frac{60 \, f_p}{n_s} \quad \rightarrow \quad f_p = \frac{100 \times 240}{60}$$

Q2 (10 marks) Answer the following questions.

Fig. 1

→ stop signal

Q1 (10 marks) Choose the correct answer for the following multiple-choice questions:

[8]

(1) Open-Loop Control System is used for:
A) Mainly in ON/Off control
B) Mainly in the indoor control systems.
C) When the actions performed by the controller are simple.
D) All of the above.

(2) The main difference between smart and traditional manufacturing systems is:
A) The structure of the traditional manufacturing systems are different from the structure of the traditional ones.
B) Smart manufacturing systems have high adaptability and responsiveness to any changes in the product and production environment than the traditional ones.
C) Traditional manufacturing systems are more reliable than smart ones.
D) Smart manufacturing systems are using up-to-date high technology more than traditional ones.

(3) In which of the following manufacturing automation levels production scheduling is taking place:
A) Factory level.
B) Enterprise level.
C) Plant level.
D) Device level.

(4) Programmable automation is more desirable for:
(A) Manufacturing systems that need high flexibility for being highly responsive to the changes in the manufacturing environment.
(B) Manufacturing systems that needs high adaptability to cope with rapid market's changes
(C) Manufacturing systems that needs high adaptability to cope with product's variety
(D) All of the above.

(5) In order to have a high production variety, the recommended type of automation to be used:
(A) Fixed automation
(B) Programmable automation.
(C) Flexible automation.
(D) B+C

(6) An actuator is:

Q3 (10 marks) Consider the automatically infusing container with liquids A and B as illustrated in Figure 2:

Fig.2
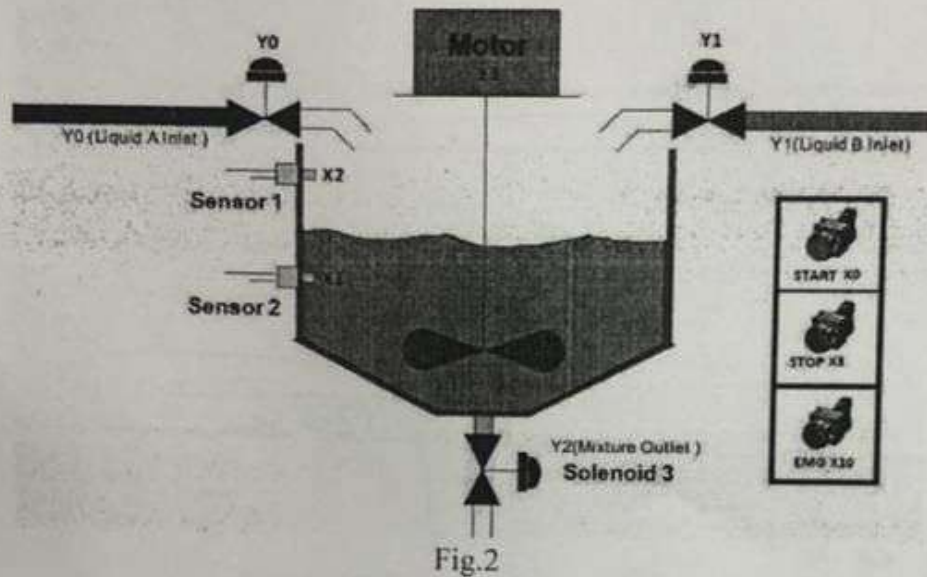
1. When X0 (start button) will be ON when START is pressed. Y0 will be ON and latched, and the valve will be opened for infusing liquid A until the level reaches the low-level set point indicated by float sensor X1.

2. X1 will be ON when the level reaches the low-level float sensor. Y1 will be ON and latched, and the valve will be opened for infusing liquid B until the level reaches the high-level float sensor X2.

3. X2 will be ON when the level reaches the high-level float sensor. Y3 will be ON and activates the motor of the mixer. Also, timer T0 will be activated and start to count for 60 sec (mixing period).

4. After 60 sec, T0 will be OFF, and the mixer motor Y3 will stop working. Y2 will be ON and latched, and the mixture will drain out of the container.

5. When Y2 = ON, timer T1 will be activated and start to count for 120 sec. After 120 sec, T1 will be Off and Y2 will be OFF. The draining process will be stopped.

6. When an error occurs, press EMERGENCY STOP button X10. The NC contact X10 will be ON to disable all the outputs. The system will then stop running.

Draw the PLC ladder diagram for the infusing container system above.

X0

T0
2sec

X0   T0   (X0)
Y0

X0   T0   (Y1)

Y1

T0   X1   (Y2)

X1

T1
60sec

X1   T1   (Y3)

T1   X1   (Y4)