

MID TERM EXAMINATION			
Semester	: Summer	Year	: 2022/ 2023
Course Title	: Industrial Automation		
Course Code	: IE0906542	Exam Version	: A

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

- (1) Open-Loop Control System is used for:
  - ☒ A) When the actions performed by the controller are simple.
  - ☐ B) Mainly in ON/Off control
  - ☐ C) Mainly in the indoor control systems.
  - ☐ D) All of the above.
- (2) The main difference between smart and traditional manufacturing systems is:
  - ☐ A) Smart manufacturing systems are using up-to-date high technology more than traditional ones.
  - ☐ B) Traditional manufacturing systems are more reliable than smart ones.
  - ☒ C) Smart manufacturing systems have high adaptability and responsiveness to any changes in the product and production environment than the traditional ones.
  - ☐ D) The structure of the traditional manufacturing systems are different from the structure of the traditional ones.
- (3) In which of the following manufacturing automation levels production scheduling is taking place:
  - ☐ A) Device level.
  - ☒ B) Plant level.
  - ☐ C) Enterprise level.
  - ☐ D) Factory level.
- (4) Programmable automation is more desirable for:
  - ☐ (A) Manufacturing systems that needs high adaptability to cope with rapid market's changes
  - ☐ (B) Manufacturing systems that needs high adaptability to cope with product's variety
  - ☒ (C) Manufacturing systems that need high flexibility for being highly responsive to the changes in the manufacturing environment.
  - ☐ (D) All of the above.
  - ☐ (E)
- (5) In order to have a high production variety, the recommended type of automation to be used:
  - ☐ (A) Flexible automation.
  - ☐ (B) Fixed automation.
  - ☐ (C) Programmable automation.
  - ☒ (D) A + C.

- (6) The purpose of signal conditioning is:  
 (A) To take the signals from the controller and prepare them for further processing.  
 (B) To take the signals from the actuators and prepare them for further processing.  
 (C) To take the signals from the sensors and prepare them for further processing.  
 (D) To boost the value of the signals to drive the actuators.
- (7) The driving force in pneumatic actuators is come from:  
 (A) Fluids.  
 (B) Electrical energy.  
 (C) Compressed air.  
 (D) Hydraulic energy.
- (8) Which of the following is correct about solenoid:  
 (A) Linear actuator.  
 (B) Electro-pneumatic or electro-magnetic actuator.  
 (C) A switching actuator.  
 (D) All of the above.
- (9) A stepper motor has a step angle of 2.5 degree. Determine number of steps required for the shaft to make 25 revolutions.  
 $\alpha = \frac{360}{n_s}$        $\alpha = 2.5^\circ$   
 $n_s = 144 \text{ step}$        $n_s = ??$   
 $A_m = n_p \alpha$        $(25)(360) = 9000$   
 $9000 = n_p (2.5)$   
 (A) 3600.  
 (B) 2500.  
 (C) 1500.  
 (D) Can't be determined.
- (10) In 9, what pulse frequency is required for the motor to rotate at a speed of 100 rpm (rev/min)?  
 $N = \frac{60 f_p}{n_s}$   
 $= \frac{60 f_p}{1}$   
 (A) 6.00 kHz.  
 (B) 3.50 kHz.  
 (C) 800 Hz.  
 (D) 12.00 kHz.

Q2 (10 marks) Answer the following questions.

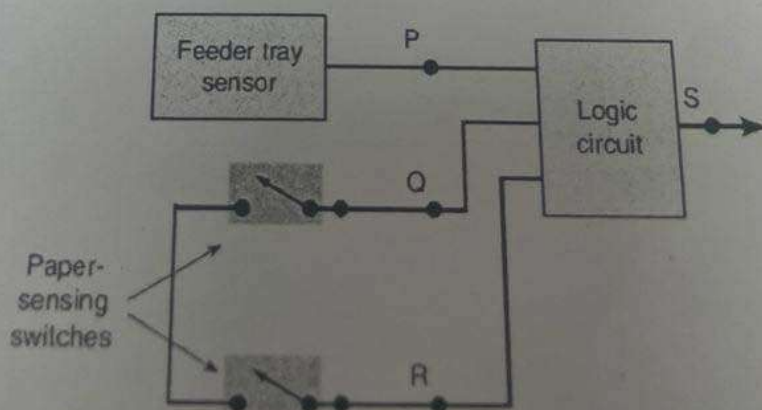


Fig. 1



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:

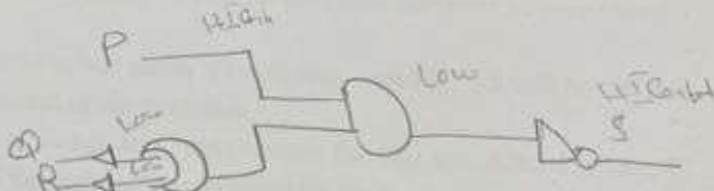
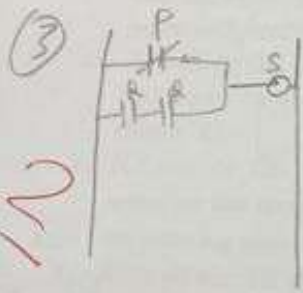
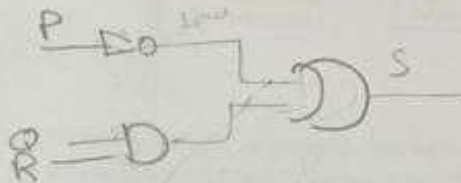
- (1) There is no paper in the paper feeder tray; or
- (2) The two switches in the paper path are activated, indicating a jam in the paper path.

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.

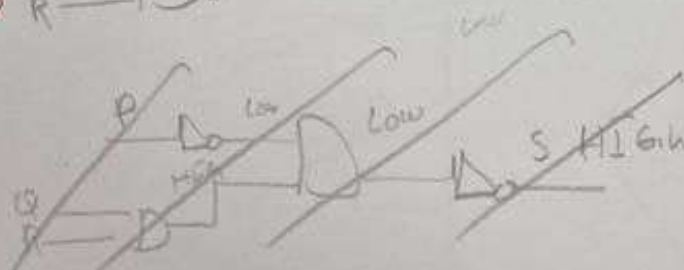
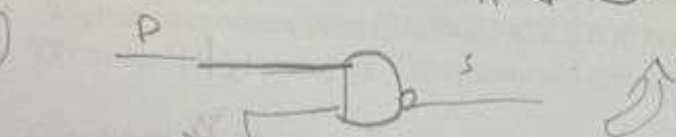
- 1) What is the logic function that represents the output signal S for the stated conditions?
- 2) Design the logic circuit to produce a HIGH at output signal S for the stated conditions.
- 3) Based on (2) design the ladder diagram for the logic circuit.
- 4) Based on (2) redesign the logic circuit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

①  $S = \text{LOW}$   $P(s)$

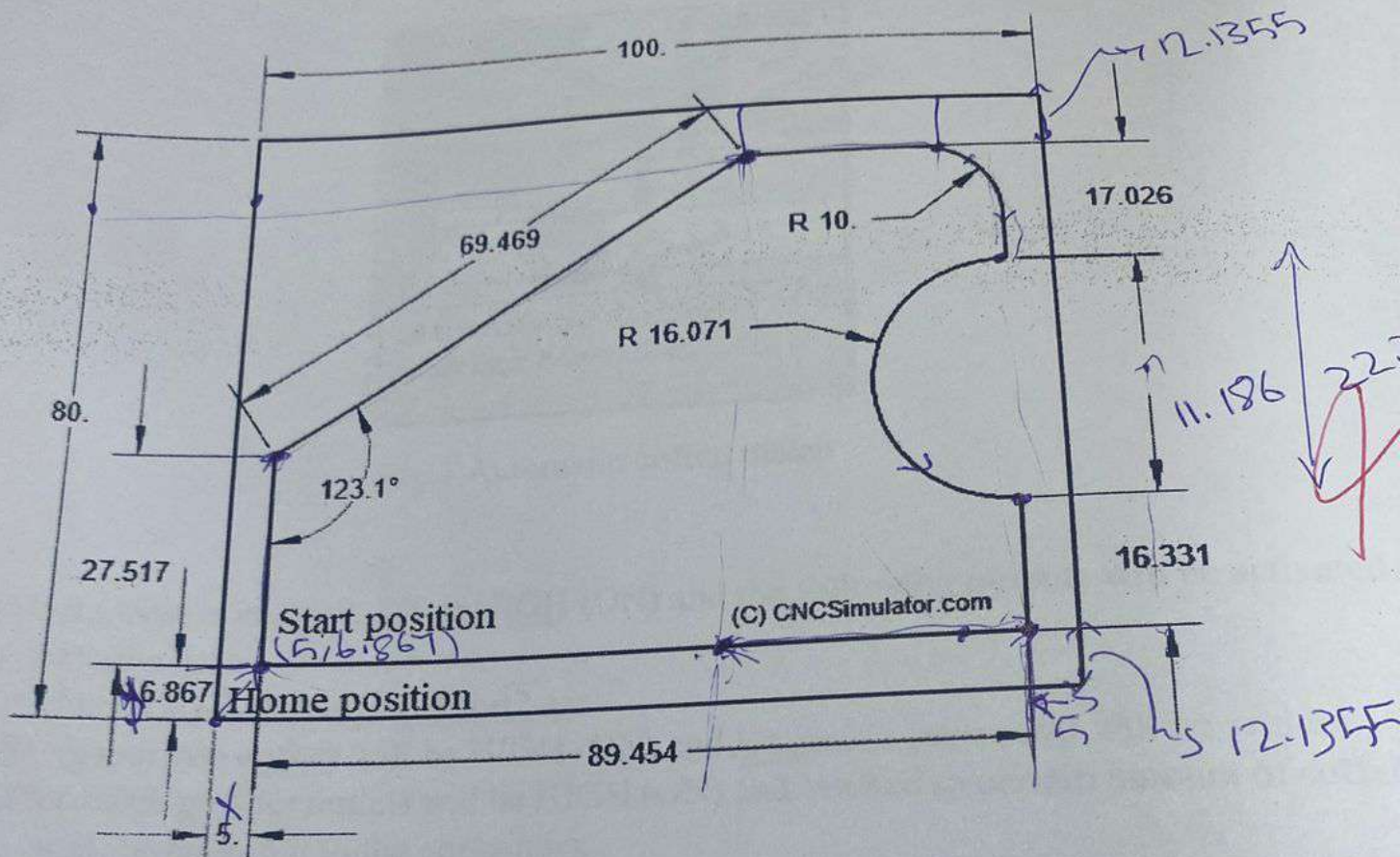
②



④



Q3) (5 marks) Write the G & M code program to do the following counter milling.



690

$G_{00} \quad x_0 \quad y_0$

601 x5 y27517

601 ~~X~~ 469.469

~~GOI~~ ~~Handwritten text~~  $\rightarrow$  GOI  $\times$

G02  $\times 89.454$  y 17.026 R10

603 X84.454 Y 22.372 R.16.071

$$501 \times 89.454 \neq 16.331$$
$$500 \times 5 = 2500$$



(6) An actuator is:

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

(7) An example of rotary actuator is:

- (A) Pneumatic solenoid.
- (B) Butterfly valve.
- (C) AC motor.
- (D) Hydraulic piston.

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

- (A) Stepper motor is actuated by a digital signal while servomotor is actuated by analogue signal.
- (B) Stepper motor can drive lower torque than servomotor.
- (C) Open loop control is required to control stepper motor, while closed loop control is required to control servomotor.
- (D) A + 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) 3600.
- (B) 2400.
- (C) 1500.
- (D) Can't be determined.

$$\alpha = 1.5 \quad n_s?$$

$$1.5 = \frac{360}{n_s}$$

$$1.5 n_s = 360$$

$$1 \text{ rev} \rightarrow 360 \text{ deg}$$

$$10 \rightarrow 3600$$

$$n_s = 3600$$

$$\alpha = \frac{360}{n_s}$$

$$1.5 = \frac{360}{n_s} \quad 1.5 n_s = 360$$

(10) In 9, what pulse frequency is required for the motor to rotate at a speed of 100 rpm (rev/min)?

- (A) 400 Hz.
- (B) 800 Hz.
- (C) 200 Hz.
- (D) 1200 Hz.

$$f_p?$$

$$N = 100 \text{ rpm}$$

$$N = \frac{60}{100} = \frac{60}{2400}$$

$$N = \frac{60}{n_s}$$

$$100 = \frac{60}{n_s} \quad n_s = \frac{60}{100} = \frac{60}{2400}$$

$$n_s = 2400$$

$$100 = \frac{60}{n_s} \quad n_s = \frac{60}{100} = \frac{60}{2400}$$

$$240000 = 60 \text{ Hz}$$

Q2 (10 marks) Answer the following questions.

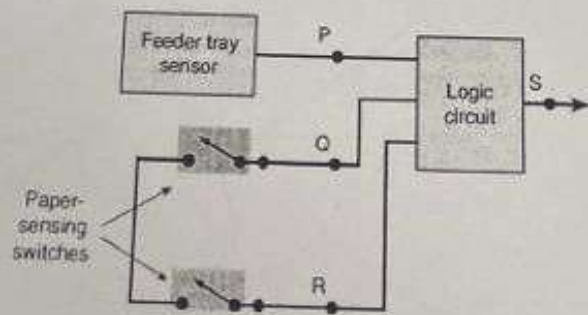
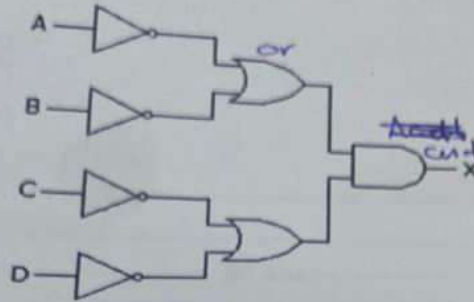
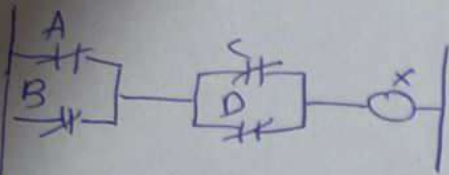


Fig. 1

Q1 (5 marks) Draw the ladder diagram for the following logic combinational circuit:

Hiba Anjad Al-Jarhi 0197742

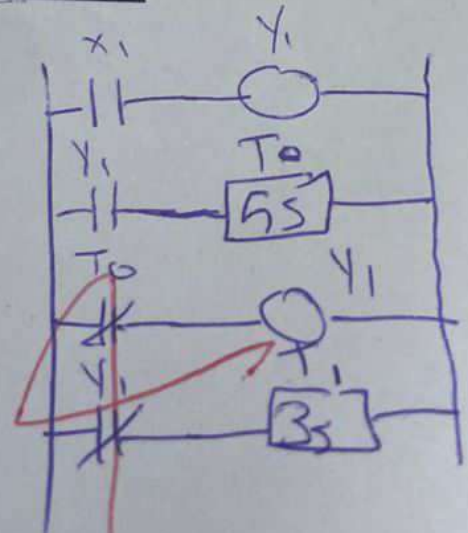
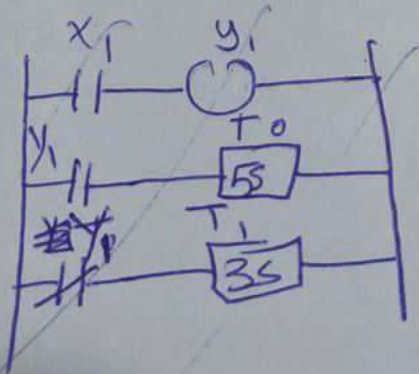
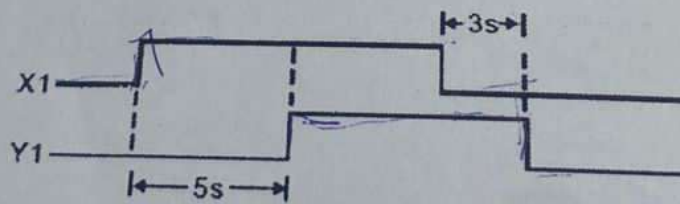
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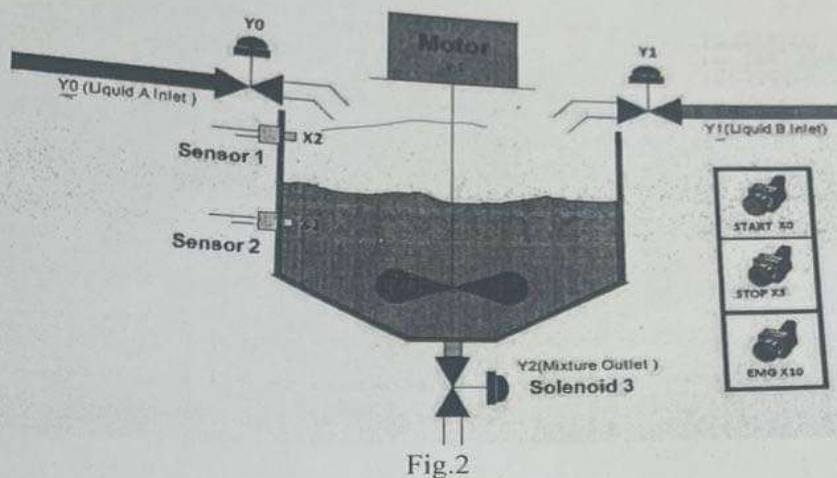
Q2 (5 marks) Draw the ladder diagram for an indicator system with the following timing signal and devices:

Enabling the indicator (Y) to be ON after a 5 sec delay (T0), and OFF after 3 sec delay (T1) by switch (X1). X1 will be on when the switch is turned ON.



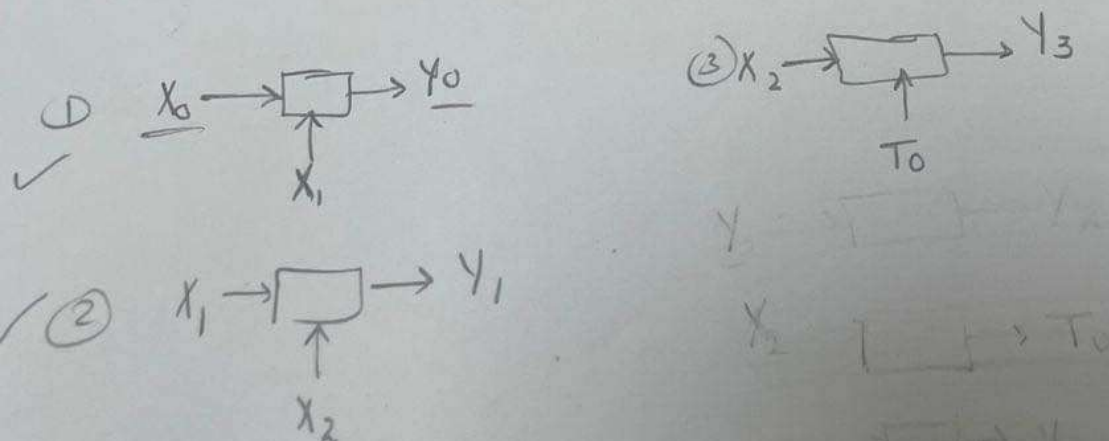


Q3 (10 marks) Consider the automatically infusing container with liquids A and B as illustrated in Figure 2:



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.





- (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  $1.5^\circ$ . Determine number of steps required for the shaft to make 10 revolutions.

- (A) Can't be determined.  
 (B) 1500.  
 (C) 2400.  
 (D) 3600.

$$\alpha = \frac{360}{n_s} \rightarrow n_s = \frac{360}{1.5} \times 10 = 2400$$

(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.

$$P_p \text{ speed} = \frac{60 P_p}{n_s} \rightarrow P_p = \frac{100 \times 240}{60}$$

Q2 (10 marks) Answer the following questions.

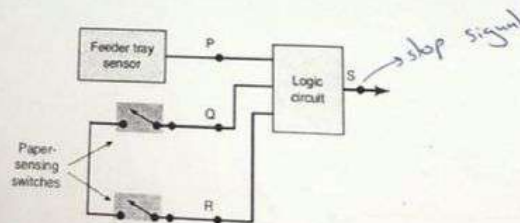
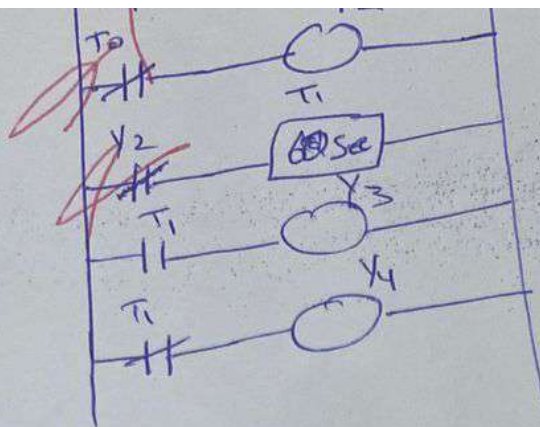


Fig. 1

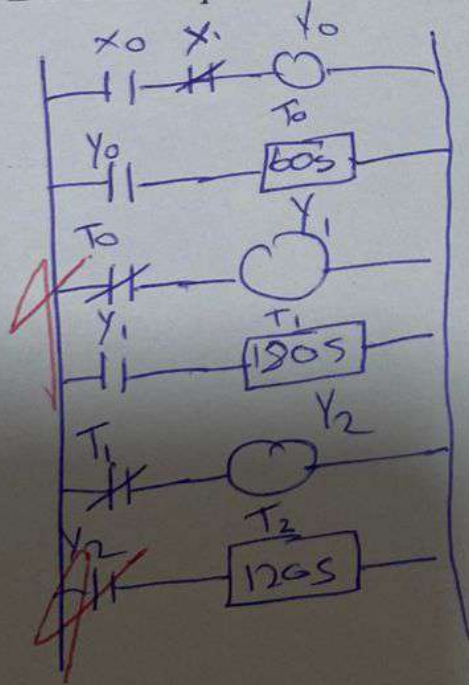






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- 4 marks) Design ladder diagram for an oven. The operations are as listed below:
1. An operator presses a start button and an ALARM output is turned on for 1 minute.
  2. The ALARM output is turned off and the HEAT is turned on for 3 minutes to allow the temperature to rise to the acceptable range.
  3. The CONVEYOR output is turned on.
  4. If the STOP input is activated (turned off) the HEAT will be turned off, but the CONVEYOR output will be kept on for two minutes.



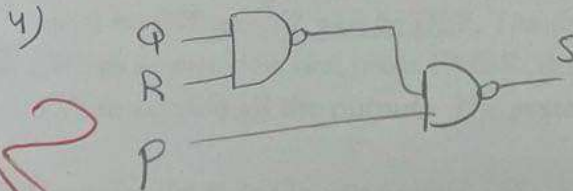
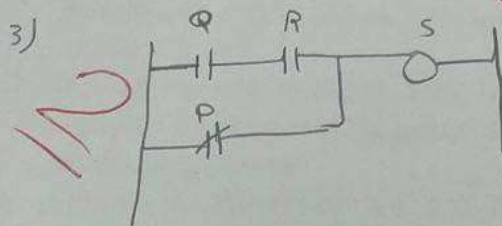
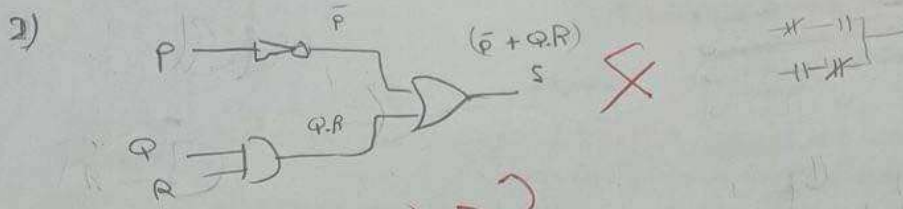
12

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?  $S = \bar{P} + Q \cdot R$
- 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.

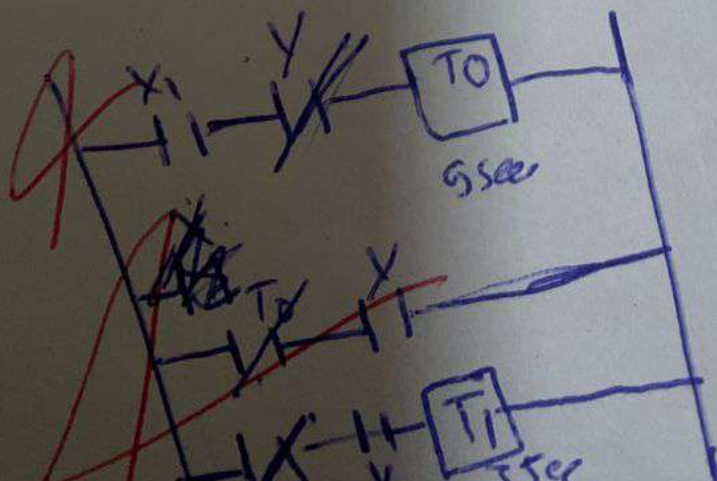
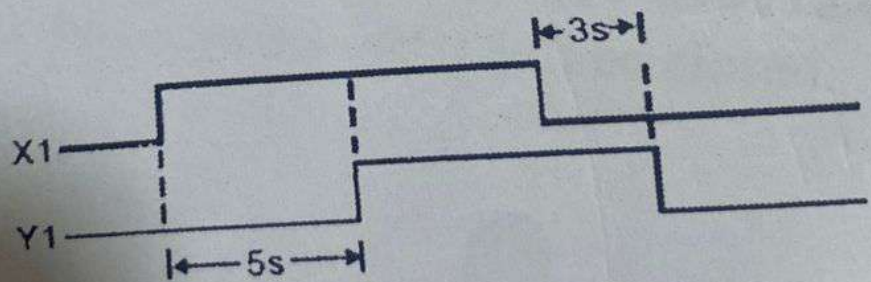


P	Q	R	Y
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	0



arks) Draw the ladder diagram for an indicator system with the following  
l and devices:

ling the indicator (Y) to be ON after a 5 sec delay (T0), and OFF after  
by switch (X1). X1 will be on when the switch is turned ON.





- (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.

Rotary hydraulic  
pneumatic

(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.

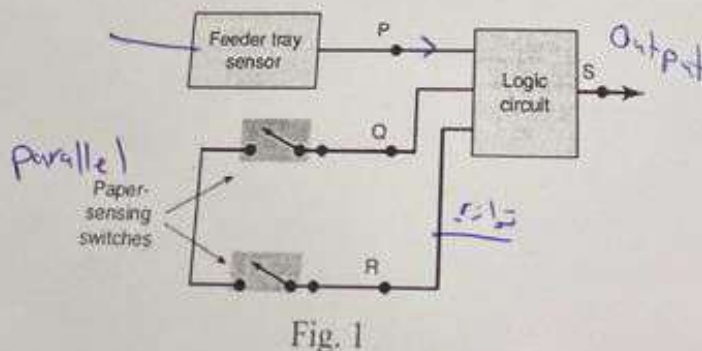
$$N_s = \frac{360}{1.5} \times 10 = 2400$$

(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.

$$N = \frac{60 \times P}{P \times S} \times 100 = 400 \text{ Hz}$$

Q2 (10 marks) Answer the following questions.



$$P + (Q \cdot R)$$



# MIDTERM EXAMINATION

Semester	: Summer	Year	: 2022/ 2023
Course Title	: Industrial Automation		
Course Code	: IE0906542	Exam Version	: C

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

[9]

(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:



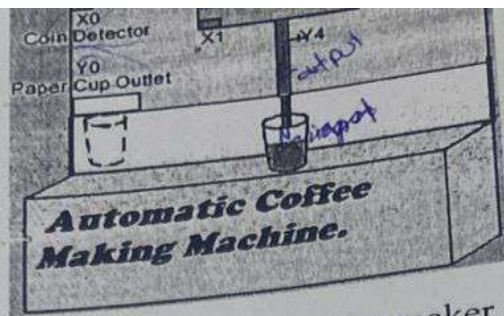
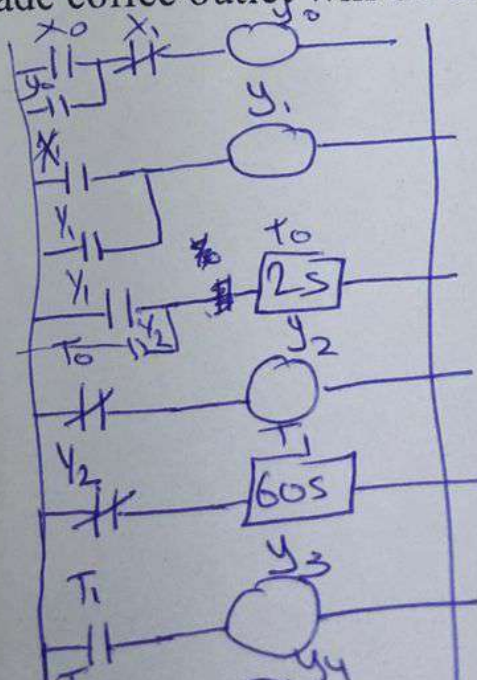


Fig.1 Automatic coffee maker

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:
  - 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 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.

For the system above:

Draw the PLC ladder diagram.





## MIDTERM EXAMINATION

Semester	: Summer	Year	: 2022/ 2023
Course Title	: Industrial Automation		
Course Code	: IE0906542	Exam Version	: B

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

- (1) Automation and control are related to each other as :
- ☒ A) Automation is a multi-level control, monitoring and supervising process.
- ☐ B) Automation system is a special case of control system.
- ☐ C) Automation and control are the same.
- ☒ D) Control is a broad branch of automation.
- (2) The three basic elements of any automation system are:
- ☒ A) Controller, sensors and actuators.
- ☐ B) Software, hardware and power.
- ☒ C) Power, control system and program of instructions.
- ☐ D) B + C.
- (3) Which of the following sentences is true about the automation hierarchy:
- ☒ A) Automation becomes more about planning and supervising as we go up from the field level to the company level.
- ☐ B) Automation becomes more about control as we go up from the field floor level to the company level.
- ☐ C) Automation becomes more about planning and supervising as we go down from the field level to the company level.
- ☒ D) All of the above
- (4) In which of the following manufacturing automation levels process planning is taking
- ☒ A) Device level.
- ☐ B) Plant level.
- ☐ C) Enterprise level.
- ☐ D) Factory level.
- (5) In order to have a high production volume, the recommended type of automation to
- ☒ A) Flexible automation.
- ☐ B) Fixed automation.
- ☐ C) Programmable automation.
- ☒ D) A + C.