UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 7 Examination in Engineering: July 2016

Module Number: ME 7313 **Module Name: Industrial Automation and Control**

[Three Hours]

[Answer all questions, each question carries **twelve** marks]

You may make additional assumptions where necessary, but clearly state them in your answers. Symbols stated herein denote standard parameters.

Q1. a) State two categories or levels of a production systems

[1.0 Mark]

b) State three reasons for automating certain processes and three reasons for not automating certain processes.

[3.0 Marks]

c) You are asked to automate a production system which is running manually at present. Describe an automation principle that you can use for the task.

[3.0 Marks]

d) The degree of automation is a function of production quantity and product variety. What are the three main types of automation and how would you relate those types of automation to production quantity and product variety?

[5.0 Marks]

Q2. A sensor is a device designed to detect, measure or record physical phenomena such as radiation, heat, pressure, presence and etc.

a) State two major non-contacting sensing technologies used in the industry while providing an application for each.

[2.0 Marks]

b) State the importance of knowing standard output frequency of a sensor when using it for an application in real world.

[2.0 Marks]

c) What is meant by 'hysteresis' in discrete sensing? Explain your answer with a suitable figure.

[2.0 Marks]

d) Briefly explain the following terms related to a sensor.

I) Observable time

II) Critical response time with respect to on-delay

[2.0 Marks]

Q2 is continued to next page....

e) Figure Q2 (e) shows a beam sensor which is employed to detect moving targets. The diameter of the sensor beam is 'a' and the length of the target is 'b'. If the target is moving at a velocity of V.

I) Derive an equation for the observable time of the sensor.

II) What is the minimum target speed for an on-delay of 20 ms? Assume; a=20mm and b= 40 mm.

[4.0 Marks]

Q3. a) State four disadvantages of using pneumatic systems.

[1.0 Mark]

b) Compressed air used in pneumatic systems needs good preparation. State three possible consequences of non-prepared air usage on system and environment.

[2.0 Marks]

c) Design a control circuit for a double acting pneumatic cylinder where the forward and the backward strokes can be controlled using 2/2 push button operated, spring return valves. Actuator should remain at the gained position once button is released.

[3.0 Marks]

d) Figure Q3 (d) shows a press machine which is occupied in a plastic manufacturing plant. An electro-pneumatic system is used to operate it. Once switched ON, the machine should satisfy following requirements,

- The operator can control the movement of top half of the die using two electrical push buttons; PB1 and PB2.
- When PB1 is pressed, top half of the die should move down.
- When the limit switch (LS) is activated, the die will remain its position for 5 s (Using an on-delay relay) and retract. The operator has to manually press PB1 again for the next cycle.
- When PB2 is pressed, the process will stop immediately and the die will move to the initial position.

Draw both electrical circuit and pneumatic circuit diagrams for the above system.

[6.0 Marks]

Q4. a) Describe main scan cycles of a typical PLC.

[2.0 Marks]

b) Use the latching concept to construct a PLC ladder program to power-on and power-off a lamp using a single push button. Here, you are only allowed to use normally-open, normally-close contacts and output coils. If necessary, memory bits can be used. The cycle should run continuously satisfying following conditions,

-1st press: Lamp is ON

-2nd press: Lamp is OFF

[3.0 Marks]

Q4 is continued to next page....

c) Figure Q4 (c) shows a length-based sorting conveyor system in an assembly plant. The "system start" and "system stop" is done using a detent (selector) switch. The Conveyor is used to sort-out metal bars of 15cm and 30cm.

- The system has two push buttons to operate the conveyor, One start button(Normally Open) to start the conveyor in single press and one stop button(Normally Close) to stop the conveyor in single press.
- Once the stop button is used, the start button should be pressed twice to start the conveyor again. [At the "system start" mode of the selector switch , a single press of start button should start the conveyor]
- Three metal sensors are used to detect the length
- Pneumatic actuators; P1 and P2 are used to sort long metal bars in to bin A and short metal bars in to bin B.
- The pneumatic actuators are actuated when the middle point of the bar is aligned with the center line of the cylinder rod.
- Conveyor belt moving speed: $2.5ms^{-1}$

Construct a PLC ladder program (Siemens STEP 7 for 300 series) for the above system satisfying all given conditions.

[7.0 Marks]

Q5. Figure Q5 shows a parking area which has one entrance gate and one exit gate. The park can only accommodate 20 vehicles. At the entrance gate, a green bulb is kept ON as long as the parking slots are available. When the park is full, a red bulb is ON and remains its state. Vehicles are not allowed to enter through the exit gate or exit through the entrance gate. The gates are electrically motorized. Both gates are to be fully automatically operated by detecting vehicles. It is required to avoid all possible accidents which could occur at the time of opening and closing the gates.

It is required to develop the system considering suitable feedback, timing and other redundancies. Siemens S300 PLC unit can be used as the controller. Four or less laser break beam sensors can be occupied to maintain the feedback loop. When the laser beam is disturbed by a vehicle, sensor output will be low. Otherwise, it will show a high voltage output.

Note: You may write additional assumptions wherever necessary.

a) Identify the signal inputs and signal outputs of the PLC. Clearly label them with standard notations. One is illustrated below.

Inputs	Outputs
I0.0 - Laser beam sensor 1 (or LBS 1)	Q0.0 - Green bulb

[1.0 Mark]

Q5 is continued to next page....

b) Clearly explain the placement of laser break beam sensor(s) using necessary sketches. (The placement has to full fill feedback requirements)

[2.0 Marks]

c) Develop a logic sequence (program logic) for the automated parking system using flow charts.

[3.0 Marks]

d) Construct a PLC ladder program to implement the above logic sequence.

[6.0 Marks]

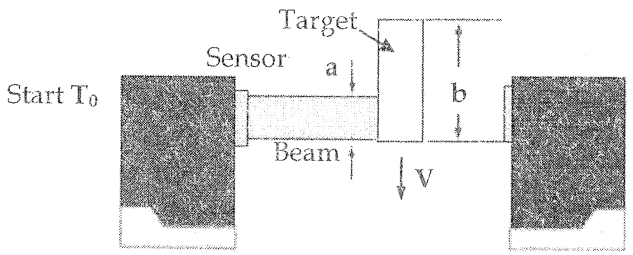

Figure Q2(e): Beam Sensor

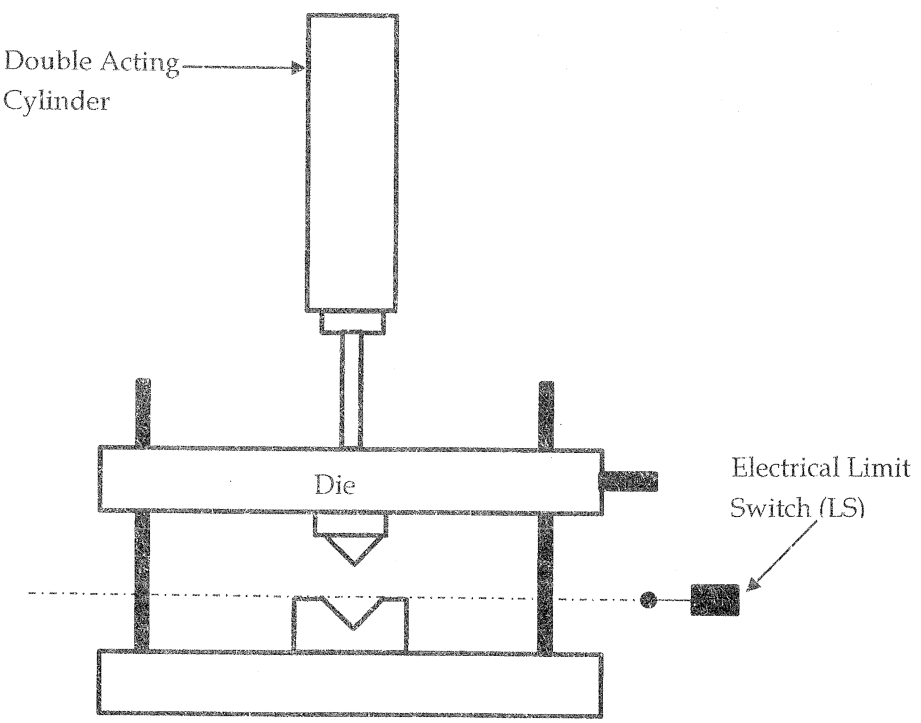

Figure Q3(d): Press Machine

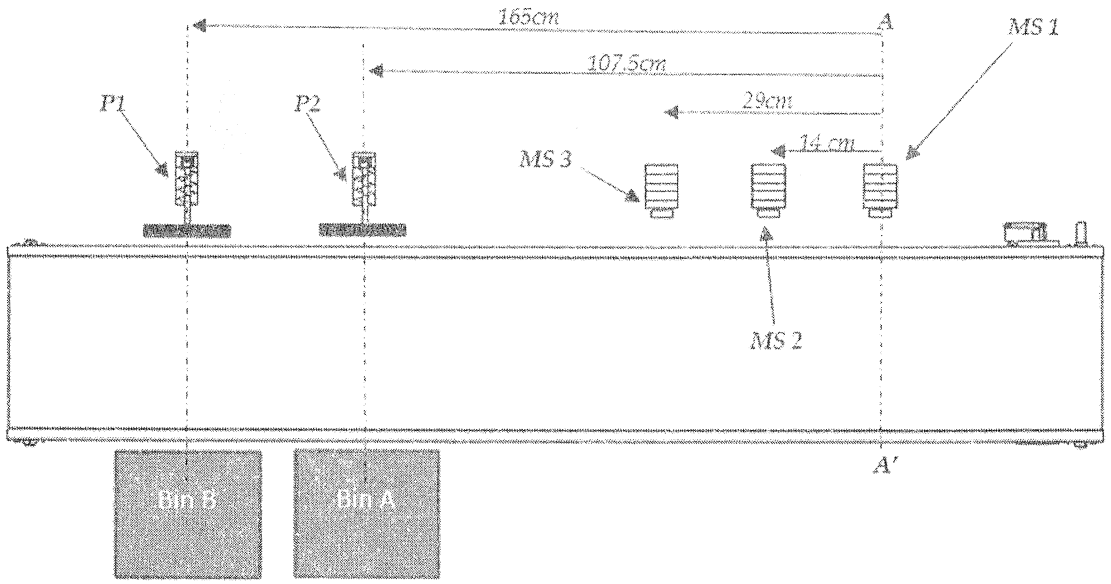

Figure Q4(c): Conveyor System

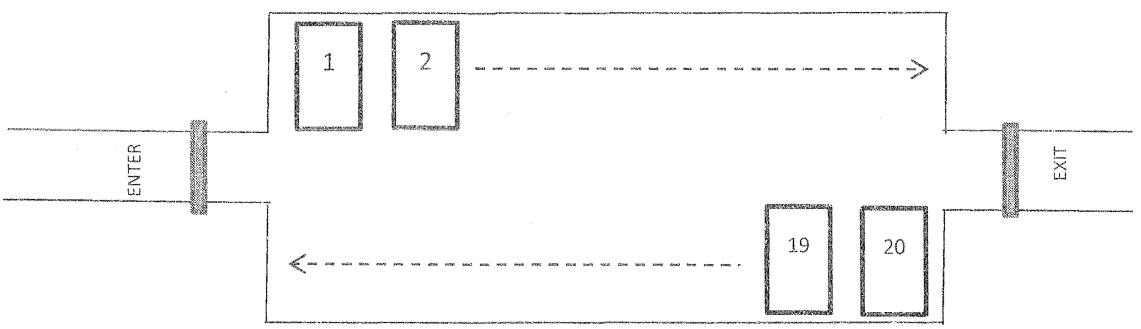

Figure Q5: Parking Area