UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 7 Examination in Engineering: July 2017

Module Number: ME7313 **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 levels of a production system.

[1.0 Mark]

b) State four situations in which manual labor is usually preferred over automation in the current context?

[2.0 Marks]

c) You are asked to automate a production system which is operated manually at present. Describe your attempt using *"Ten strategies for automation and production systems"*.

[4.0 Marks]

d) The degree of automation can be described as 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 The Engineering Workshops of the Department are used by the students for their project work apart from other discrete jobs requested time-to-time by inside/outside customers. The workshops are opened during the daytime on working days and sometimes in nights when required. Due to the recent increase in electricity tariffs, the electricity bill of the workshops has increased drastically. After a careful investigation by an expert team, it was found that the use of electrical lighting, fans, and air conditioners are not controlled by any means; even when people are not using any of them. Furthermore, the electricity consumption by the various machines contributes to the electricity bill increase. Therefore, it was decided to implement an energy management program to minimize the energy wastage. As the initial step, it was proposed to design and implement an automated electrical lighting control, fan control, and air conditioning control system; while the machine operators are given the responsibility of efficient use of the other workshop machinery. As an automation engineer, you are assigned to develop and implement an automated control system for all above electricity consuming devices (except the workshop machinery), which must be integrated with a Supervisory Control and Data Acquisition (SCADA) system.

a) What are the major factors to be considered in designing an automated system for minimizing the inefficient use of electrical/ electronic devices?

[3 Marks]

Q2 is continued to next page....

b) What are the physical parameters you are going to monitor/sense? Name the type of sensors, actuators, and controllers required for implementing the proposed SCADA system. Comment about the suitability of suggested sensors for the given application based on their accuracy and operating ranges.

[4 Marks]

c) The data acquisition and system control must utilize the already available wired and wireless Local Area Network facility in the Department. Draw a schematic diagram of the proposed automated control system and clearly indicate each sensor, actuator, and controller on the schematic diagram. You are free to make any ***reasonable*** assumption.

[5 Marks]

Q3 a) State four main stages of a pneumatic system.

[1.0 Mark]

b) Pneumatics, hydraulics and electricity are several methods of energy transmission. Make a comparison between the above three energy transmission methods based on the selection criteria below by filling the table using words low, medium and high.

	Pneumatics	Hydraulics	Electricity
Position accuracy			
Stability			
Linear motion			
Rotary motion			

[2.0 Marks]

c) Design control circuit diagram 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. The actuator should remain at the gained position once the button is released and the user should be able to adjust the speed of the backward stroke.

[3.0 Marks]

d) Figure Q3 (d) shows an electro-pneumatically operated press machine. Once switched ON, the machine should satisfy following requirements.

- The operator can control the movement of top half of the press machine using two electrical push buttons; PB1 and PB2.
- When PB1 is pressed, top half of the press machine should start to move down.
- When the electrical limit switch (LS2) is activated, the press will remain at its position for 5 s (Using an on–delay relay) and retract. When the electrical limit switch (LS1) is activated the press will start to move down again automatically.
- Up – Down movement of the press will take place until PB2 is pressed.
- When PB2 is pressed, the process will stop immediately and the press will move to the initial retracted position.

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

[6.0 Marks]

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

[2.0 Marks]

b) A,B,C and D are four push buttons in a motor control system. If A and B are pressed within 0.25 s while C is not being pressed, motor M1 should get started and remain in the state. If A and B are pressed within 0.25 s while C is being pressed, the motor M1 should get started and get switched off after 30 s. Button D is used to switch off the motor at any time. Develop a logic sequence (program logic) for this motor control system using flow charts.

[3.0 Marks]

c) A blinking bulb system should get turned on/off using a single push button.If the system is OFF, pressing the button should turn on the blinking system which will continuously run until the button is pressed again satisfying following timing. In onecycle the bulb should stay turned on for 5 s and stay turned off for 2 s. If the system in ON, pressing the same push button should turn off the system. Construct a PLC ladder program (Siemens STEP 7 for 300 series) for the above system satisfying all given conditions.

[5.0 Marks]

d) Upgrade the developed program in part c) to turn off the bulb automatically after completing 10 blinking cycles. While the blinking cycle continues, the bulb should get turned off immediately if the button is pressed regardless of completing the sequence for 10 times.

[2.0 Marks]

Q5 Figure Q5 shows a car elevator system which can be used to transport a car between the ground floor and the first floor. The elevator system utilizes a hoist which is driven by an electric motor. Two limit switches are placed at each floor level to identify the position of the hoist. There are roller doors at each floor which will get open when a car is detected and get closed only when the car is fully inside the elevator cage. Fully open and fully closed states of each roller door are identified using two limit switches. If a car is detected and has not entered to the elevator cage within 1 minute the respective door should get closed. A switchboard shown as in figure Q5 is installed inside the elevator to select the floor and stop the elevator in an emergency. Assume that all these three buttons are push buttons.

- When a car is detected at any floor the respective door should get open only if the hoist is on the same floor. If not the hoist should come to the same floor where the car is detected before opening the door.
- When the car is fully inside the cage, the roller door should get closed automatically.
- When the driver selects a floor using the switch board inside the elevator, the hoist should start and reach the selected floor.
- Once the hoist has reached the selected floor, the roller door should get open.
- Once the car has exited the cage and away from the roller door, the roller door should get closed.
- There are indicator lamps installed at each door. As long as the elevator is not occupied only the green bulb should be ON at both doors. When the elevator is occupied by a car, only the red bulb should be ON at both doors.

Q5 is continued to next page....

It is required to develop the car elevator system described above considering suitable feedback, timing and other redundancies. Siemens S300 PLC can be used as the controller.

Note: You may use additional assumptions wherever necessary. Clearly state any of your assumptions.

a) Identify the input and output signals of the system. Clearly label them using standard notations. An example is illustrated below.

Inputs	Outputs
I0.0 – Ground Floor (PB1)	Q0.0 – Roller door motor 1 - UP
	Q0.1 – Roller door motor 1 - DOWN

[1.0 Mark]

b) Arrange your sensor placement in a way which can differentiate between a car and a human (Your system should only respond to objects having a size of a car) and to avoid accidents which could occur at the time of opening and closing the roller doors. Clearly explain the placement of laser break-beam sensor(s) using necessary sketches to detect a vehicle at a door and to identify the vehicle has fully reached the inside of the elevator cage. (The placement has to fulfill feedback requirements)

[2.0 Marks]

c) Construct a PLC ladder program (Siemens STEP 7 for 300 series) to implement the above elevator system.

[9.0 Marks]

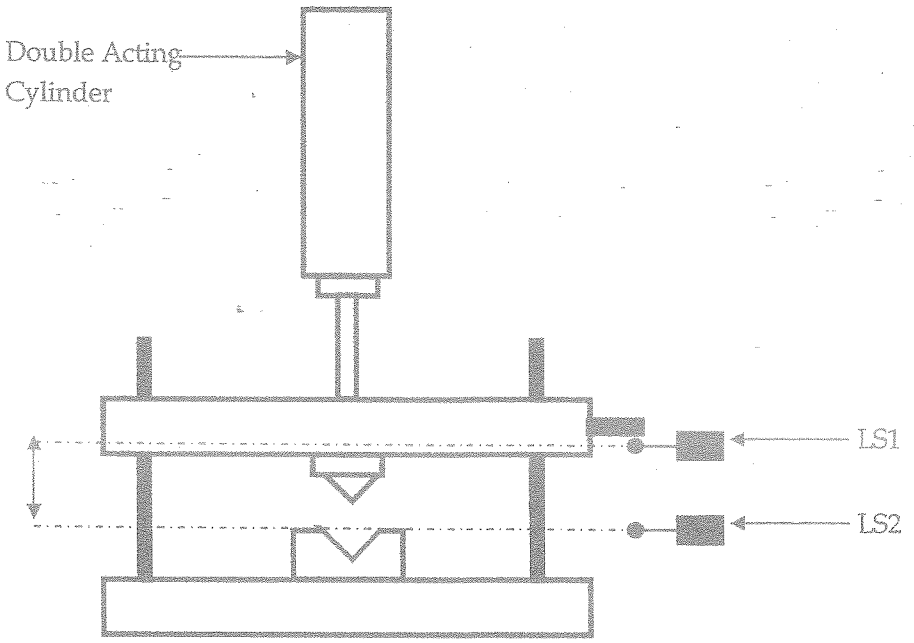

Figure Q3(d): Press Machine

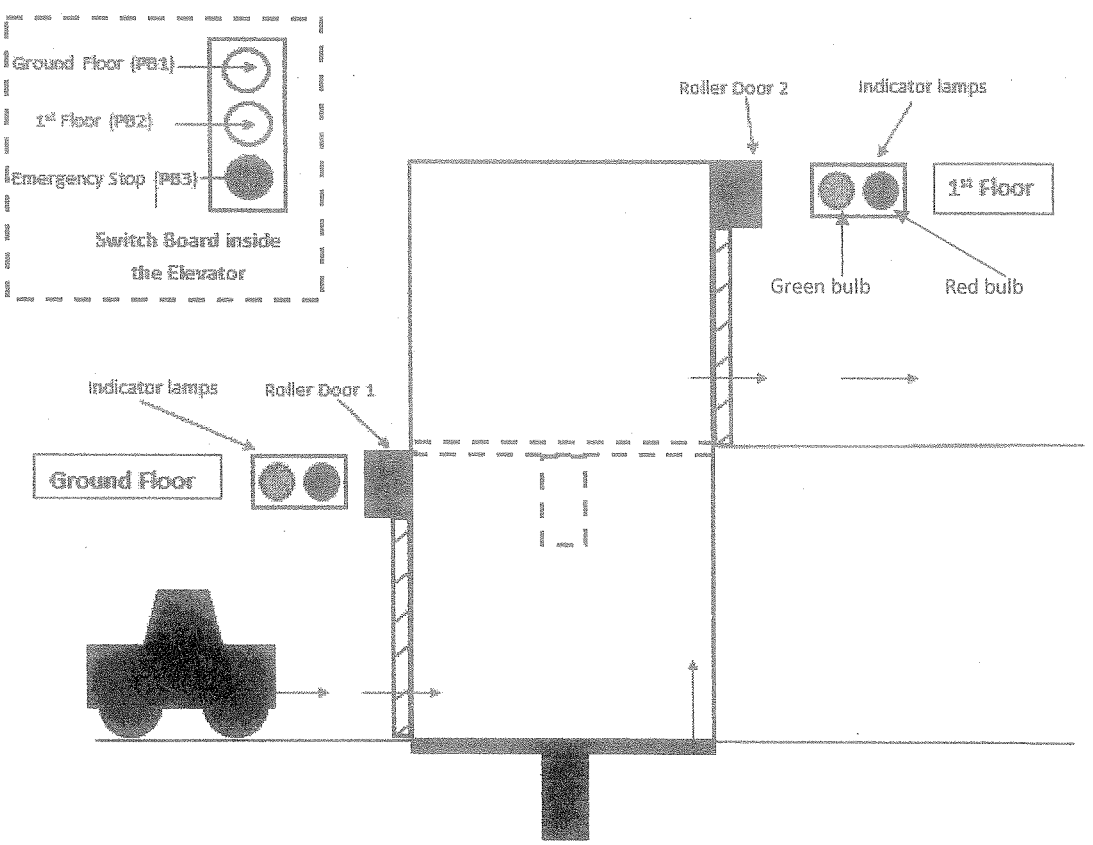

Figure Q5: Car Elevator