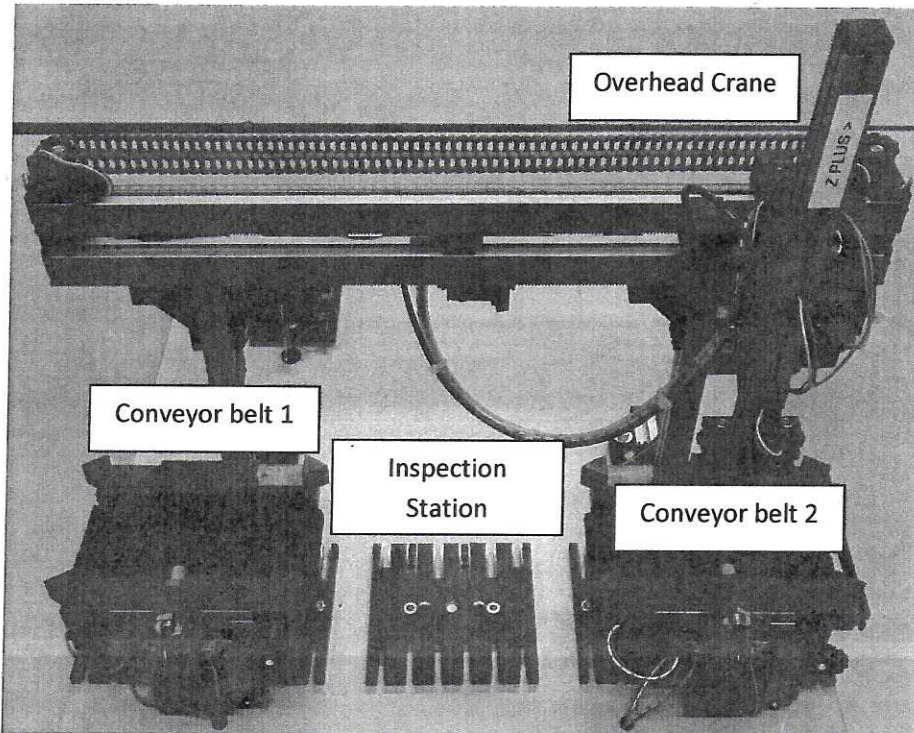


Group 1 – Boolean Algebra (10 points)

Consider the system depicted below.



The system is composed by an overhead crane, two conveyor belts and an inspection station. Each conveyor has a presence sensor that has the logic value TRUE, or 1, when a part is detected and FALSE, or 0, otherwise. The inspection station has also one such sensor. Parts cannot be placed in the inspection station or in conveyor belt 2 if they are already occupied.

When a part is placed in the inspection station it becomes busy for a given period of time. If the station is not busy and a part is on it then that part should be transferred to conveyor belt 2. If both conveyor belt 1 and the inspection station have a part that needs to be moved to conveyor belt 2 then the part in the inspection station is prioritized.

When a part is detected in conveyor belt 1 the crane reads an additional signal that has the logic value TRUE, or 1, if the part is to be transferred to the inspection station. If the signal's logic value is FALSE, or 0, the part should be transported to conveyor belt 2.

1. From the choices below please identify the one that more accurately describes the system and **explain why**:

3
points

- A. This system can be modeled by considering the following inputs: I1 – part in conveyor 1; I2 – part in inspection station; I3 – part in conveyor 2; I4 – part to station; I5 – station busy. The following output functions should be considered: F1 – move from conveyor belt 1 to inspection station; F2 – move from conveyor belt 1 to conveyor belt 2; F3 - move from inspection station to conveyor belt 2.
- B. This system can be modeled by considering the following inputs: I1 – part in conveyor 1; I2 – part in inspection station; I3 – part in conveyor 2; The following output functions should be considered: F1 – move from conveyor

belt 1 to inspection station; F2 – move from conveyor belt 1 to conveyor belt 2; F3 - move from inspection station to conveyor belt 2.

C. None of the above.

If you have selected C please describe in detail all the inputs and functions that you are considering.

4
points

2. Write the truth tables that describe the functions F1 – move from conveyor belt 1 to inspection station; F2 – move from conveyor belt 1 to conveyor belt 2; F3 - move from inspection station to conveyor belt 2 and for each function devise the most simplified expression.

3
points

3. The owner of the system has asked you to include a safety system that will detect humans in the proximity of the system. If the human gets too close, the safety system will stop the crane. Please write the new expressions of F1, F2 and F3 considering the safety system. Consider that the safety system gives you an additional input (**Is – Input Safety**) that is TRUE, or 1, when a human is detected and FALSE, or 0, otherwise. Explain why the new expressions are the way they are.

Group 2 – Programmable Logic Controllers (15 points)

Please answer the following questions considering what you have learned during the course:

5
points

1. The IEC61131-3 describes five programming languages for PLCs. Please describe each language and discuss the differences between them.

4
points

2. What is the main difference between a FUNCTION and a FUNCTION BLOCK. Provide a small example that illustrates this difference.

3
points

3. POU's have generally two parts. What should be programmed in each one of these parts.

3
points

4. From the choices below please indicate which are right and which are wrong and explain why:

- A. POU stands for Programming Oriented Unit.
- B. Variables declared as VAR can be used as input and output variables;
- C. Writing to a variable declared as VAR_INPUT in a POU from within that POU will change the value of the variable globally for other POU's or a calling POU.
- D. VAR_IN_OUT is used to declare variables that can be used as input and output variables.
- E. A VAR_IN_OUT variable once changed is changed everywhere.
- F. VAR and VAR_TEMP can be used to declare local variable within a POU.

Group 3 – Robots and Sensor (15 points)

Please answer the following questions considering what you have learned during the course:

- 3 points** 1. What are the main characteristics of a robot according to the ISO 8373?
- 2 points** 2. Explain why overloading a robot, with excessively heavy parts, will affect its accuracy and repeatability.
- 3 points** 3. What is the difference between forward and inverse kinematic?
- 2 points** 4. Which information is processed by a robot's internal and external sensors? In your answer include examples of both types of sensors.
- 2 points** 5. What are the advantages and disadvantages of using offline programming?
- 3 points** 6. Explain what a sensor is and enumerate and explain three factors that characterize a sensor.

Group 4 – Programming (10 points)

Using any of the programming languages taught in the course answer the following questions:

- 5 points** 1. Please describe the type and number of POUs that you would use to program functions F1, F2 and F3 from question 1 in group 1.
- 5 points** 2. Please write down these POUs including both the generic and the language specific part. You can use any programming language you like as long as it is from the IEC61131-3