



**PROGRAM** : BACCALAUREUS INGENERIAE  
MECHANICAL ENGINEERING

**SUBJECT** : ADVANCED MANUFACTURING SYSTEMS

**CODE** : MVS4A11

**DATE** : WINTER EXAMINATION (SUPPLEMENTARY)  
JUNE 2019

**DURATION** : (1-PAPER) 08:30 - 11:30

**WEIGHT** : 50 : 50

**TOTAL MARKS** : 100

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**EXAMINER** : Dr. N MADUSHELE

**MODERATOR** : Mr. T LEKWANA (UNISA)


**NUMBER OF PAGES** : 6 PAGES AND 1 ANNEXURES

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**INSTRUCTIONS** : QUESTION PAPERS MUST BE HANDED IN.

**REQUIREMENTS** : ANSWER BOOKLET.

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**INSTRUCTIONS TO CANDIDATES:**

PLEASE ANSWER ALL THE QUESTIONS.

**QUESTION 1**

**25 Marks**

1(a) What are manufacturing systems, and how are they distinguished from production systems? (4 Marks)

(b) Oftentimes computerization and automation are usually used interchangeably, this is incorrect, and the end result has the potential to deviate from the initial objective. With the aid of a sketch can you indicate the difference between automation and computerization? (4 Marks)

(c) Discuss the three phases of a typical automation migration strategy. (3 Marks)

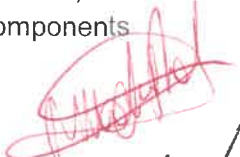
(d) Your company is planning to introduce a new product line. The new product line will include 100 different models. Annual production of each model is expected to be 1000 units. Each product will be assembled of 600 components. All processing of parts and assembly of products will be accomplished in one factory. There are an average of 10 processing steps required to produce each component, and each processing step takes 30 sec. (includes an allowance for setup time and part handling). Each final unit of product takes 3.0 hours to assemble. All processing operations are performed at work cells that each includes a production machine and a human worker. Products are assembled on single workstations consisting of two workers each. If each work cell and each workstation require 20 m<sup>2</sup>, and the factory operates one shift (2000 hr/yr), determine:

(i) The number of production operations per year, (2 Marks)

(ii) The number of workers required in the plant. (3.5 Marks)


(iii) How much floor-space is required, (2.5 Marks)

(d) A welding inspector in a factory ensures that the welds done on parts manufactured complies with a given welding standard. You want to monitor the effectiveness of your welding inspector, and you have decide to use the precision-recall measure. Where 1 is associated with welding defects and 0 is associated with welds that pass the inspection. Out of a total of 800 welds that were inspected, you found that the inspector correctly predicted that 60 parts had welding defects, and 580 parts did not have welding defects. However, the inspector incorrectly predicted that 40 parts did not have defects, and the components

  
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turned out to have defects. Finally, the inspector incorrectly predicted that 120 parts had defects, and the components turned out to not have defects.

- (i) Provide a contingency table for the analysis. (2 Marks)
- (ii) Compute the Precision of the inspector. (1 Mark)
- (iii) Compute the Recall of the inspector. (1 Mark)
- (iv) What is the inspector's accuracy? (1 Mark)
- (v) Explain your Recall answer. (1 Mark)

  
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## **QUESTION 2**

**25 Marks**

2(a) With the aid of a sketch, illustrate the elements that constitute an automated system.

(4 Marks)

(b) The 4<sup>th</sup> Industrial Revolution (4IR) brings with it a number of opportunities. One such opportunity is in the development of decision making machines. Provide at least three (3) reasons why decision-making is required in a programmed work-cycle. (6 Marks)

(c) There are three (3) advanced automation functions i.e. safety monitoring, maintenance and repair diagnostics; error detection and recovery. Discuss the status monitoring as well as the failure diagnostics involved in Error Detection and Recovery functions, and finally provide a possible response that one receives with the employment of this function. (4 Marks)

(d) Continuous controllers are used in instances wherein the objective is to maintain the value of an output variable at a desired level. Critically discuss the objective(s), performance measure(s), and the limitation(s) of a Feedforward Controller. Also provide a sketch of Feedforward Control. (6 Marks)

(e) We live in a dynamic world, and as such the process parameters of a work-cycle are continuously changing. This makes it extremely important to have real-time process control. Discuss the requirements needed to have real-time process control. (5 Marks)



### QUESTION 3

25 Marks

3 (a) Using the notation scheme for defining manipulator configurations (covered in class), draw diagrams of the following robots:

(i) TRT, (2 Marks)

(ii) VROT. (3 Marks)

(b) Industrial robots have a number of configurations, some even have anthropomorphic (human-like) features. Industrial robots are fundamentally comprised of joints, links, and manipulators. Against this background, critically discuss the anatomy of industrial robots.

(6 Marks)

(c) In industrial robots, what is a joint drive system? List the three (3) joint drive systems used, also provide distinctive features of each joint drive system.

(4 Marks)

(d) An industrial robot performs a machine loading and unloading operation. A PLC is used as the robot cell controller. The cell operates as follows: (1) a human worker places a workpart into a nest, (2) the robot reaches over and picks up the part and places it into an induction heating coil, (3) a time of 10 seconds is allowed for the heating operation, and (4) the robot reaches in and retrieves the part and places it on an outgoing conveyor. A limit switch X1 (normally open) will be used in the nest to indicate part presence in step (1). Output contact Y1 will be used to signal the robot to execute step (2) of the work cycle. This is an output contact for the PLC, but an input interlock for the robot controller. Timer T1 will be used to provide the 10 second delay in step (3). Output contact Y2 will be used to signal the robot to execute step (4). (a) Construct the ladder logic diagram for the system.

(10 marks)



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#### QUESTION 4

**25 Marks**

4(a) What is the difference between fixed routing and variable routing in manufacturing systems consisting of multiple workstations? (5 Marks)

(b) With an increased use of automated industrial robots, labour unions have argued that the robots are taking human-workers employment. It is also argued that the manning level is inversely correlated with automation levels in a manufacturing system. Why is this the case? (2 Marks)

(c) Flexibility is the attribute that allows a mixed-model manufacturing system to cope with a certain level of variation in part or product style without interruptions in production for changeovers between models. Against this background, what are the three capabilities that a manufacturing system must possess in order to be flexible? (3 Marks)

(d) An automated guided vehicle system is being proposed to deliver parts between 40 workstations in a factory. Loads must be moved from each station about once every hour; thus, the delivery rate = 40 loads per hour. Average travel distance loaded is estimated to be 250 m and travel distance empty is estimated to be 300 m. Vehicles move at a speed = 200 m/min. Total handling time per delivery = 1.5 min (load = 0.75 min and unload = 0.75 min). Traffic factor  $F_t$  becomes increasingly significant as the number of vehicles  $n_c$  increases; this can be modeled as:

$$F_t = 1.0 - 0.05(n_c - 1) \quad \text{for } n_c = \text{Integer} > 0$$

Determine the minimum number of vehicles needed in the factory to meet the flow rate requirement. Assume that availability = 1.0 and worker efficiency = 1.0. **NB: Also provide a check for your computation** (15 Marks)



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