

**IE 372 Simulation**  
**Spring 2023**  
**Assignment 3**  
**Due Date: 12<sup>th</sup> May 2023**

**(This assignment must be solved in teams of three)**

Consider a painting and assembly department (PAD) where two types of components sent from the manufacturing department are processed. The first type of components, which are to be painted and polished, arrive at PAD according to an exponential distribution with a mean of 22 minutes. The second type of components, which should go through two different operations, arrive at PAD with exponentially distributed interarrival times again with a mean of 22 minutes. Upon completion of both types of components, one type 1 and one type 2 components are assembled and packaged. After the packaging operation, they are sent to finished goods inventory.

There are two color options for type 1 components. 15% of them are painted in white and 85% in black. Regardless of their color, all type 1 components are prepared before they are painted. PAD has a single preparation machine. Preparation process time is distributed normally with a mean of 6 minutes and standard deviation of 2 minutes. Also, preparation machine gives priority to the components to be painted in white.

After preparation, the components are sent to the painting area, where a single painting machine processes the components. Painting times of the components differ according to the color and are given in Table 1. If a component is to be painted in a different color than the previously painted component, then a setup for cleaning is required and a machine cleaning time must be added to the painting time. If the previous component was painted in white and the current component is black, then machine cleaning time is 5 minutes. However, if the previous component was painted in black and the current component is white, then cleaning the machine lasts 18 minutes. After each painting process, the components waiting to be painted are checked and the first one that has the same color as the last painted component is selected for painting to reduce total cleaning time of the machine. If there are not any components to be painted in the same color, then first come first served rule is applied among the components with different color.

Table 1. Process Times for Type 1 Components (in minutes)

	White	Black
Painting	NORM(10,2)	NORM(12,4)
Polishing	12	17

After the painting, the polishing process begins. Different colored components enter different queues and they are polished by different machines in batches. Their polishing times are also given in Table 1. A batch of white components consists of 3 components, and a batch of black components consists of 5 components. After the polishing process ends, a type 1 component, regardless of its color, should be assembled with a finished type 2 component.

Type 2 components must go through two different operations where the order of operations is not important. There are two operators; one is responsible for operation A and the other is responsible for operation B. These operators also have separate queues. When it arrives at PAD, a type 2 component selects the operation having the shortest queue. If the numbers of components in both queues are the same, it joins the queue of operation A. Process times are distributed as TRIA(2,3,7) for operation A, and TRIA(3,6,9) for operation B. Both operators give priority to a component, if this operation is the last operation of that component. In order to be assembled with a type 1 component, a type 2 component should complete both operations.

After the assembly of a type 1 and a type 2 components, the assembled product is packaged. There are two identical packaging machines in PAD and the packaging time is distributed normally with a mean of 14 minutes and a standard deviation of 2 minutes. After the packaging is complete, the product leaves the PAD and is sent to finished goods inventory.

- a) Simulate this system for 30 days, and collect your own statistics on the following.
- Flow time of type 1 components (the time between arrival at PAD and finishing polishing process)
  - Flow time of type 2 components (the time between arrival at PAD and finishing both operations)
  - Total number of setups of the painting machine
  - Average machine cleaning time spent for the painting machine
  - Utilization of the packaging machines
  - Average number of type 1 components in preparation queue
- b) Make 10 replications, each of length 30 days. Using replication averages as 10 observations, construct a 95% confidence interval for the expected flow time of the first type of components sent to the assembly department.