**Problem 2**

**(a)**

**Queueing model:**

**Diagram

Description automatically generated**

**Summary of arrival rates and service rates:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Station** | **Arrival rate For 8% trauma (per min)** | **Arrival Rate for 12% trauma (per min)** | **Service rate (per min)** |
| Sign-in |  |  | 0.3333 |
| Registration |  |  | 0.2 |
| Examination |  |  | 0.0625 |
| Trauma |  |  | 0.0111 |
| Treatment |  |  | |  |  | | --- | --- | | For 8% | For 12% | | 0.0683 | 0.0653 | |

**Computation of arrival rates (table 1):**

|  |  |  |
| --- | --- | --- |
| **Station** | **For 8% trauma patients** | **12% trauma patients** |
| Sign-in |  |  |
| Registration |  |  |
| Examination |  |  |
| Trauma |  |  |
| Treatment |  |  |

**Staff needed to just keep-up (table 2):**

|  |  |
| --- | --- |
| For 8% trauma patients | For 12% Trauma Pacients |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

**Computations for the needed staff just to keep up:**

|  |  |
| --- | --- |
| Computations of staff for 8% trauma: | Computations for 12% trauma: |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

Note:

**(b)**

For Rayleigh distribution: mean = , and variance =

Registration station: 3.9894

variance =

Treatment Station:

By the theory, we have that:

Note for the next exercises:

Let be the random variable that represent the contact time of the patient that comes from the trauma station. Similarly, for the patients that come from the examination station. Since these two random variables are independent of each other,

Variance(== 42.7190

We will use this variance number to model the trauma station as a M/G/c for the remaining exercises

**(c)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Station** | **Waiting time (in minutes)** | **FirstTreatment**  **Standards** | **Root mean squared deviation** |
| Sign-in | 1.117 | 6 | 0.8138 |
| Registration | 3.641 | 10 | 0.6359 |
| Examination | 69.296 | 15 | 3.6197 |
| Trauma | 321.695 | 2 | 159.8475 |
| Treatment | 11.614 | 15 | 0.2257 |
| Total: | | | 165.1426 |

**(d)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Station** | **Minimum number of staff** | **Mean Waiting time (wQ) in minutes** | **FirstTreatment**  **Waiting time Standards**  **(minutes)** | **Root mean squared deviation** |
| Sign-in | 2 | 1.117 | 6 | 0.8138 |
| Registration | 2 | 4.463 | 10 | 0.5537 |
| Examination | 6 | 3.998 | 15 | 0.7335 |
| Trauma | 8 | 0.905 | 2 | 0.5475 |
| Treatment | 4 | 11.614 | 15 | 0.2257 |
| Total: | | | | 2.8742 |

Note that if we add 1 minute (average time to move 1 patient between stations) to the waiting time of each station we still are below the FirstTreatment waiting standards for any station. Therefore, the time of moving patients from one station to another can be ignored.

**(e)**

Increasing staff:

|  |  |  |  |
| --- | --- | --- | --- |
| **Station** | **Minimum number of staff** | **Root mean squared deviation (adding 1 to the optimal staff #)** | **Root mean squared deviation (adding 2 to the optimal staff #)** |
| Sign-in | 3,4 | 0.9743 | 0.9960 |
| Registration | 3,4 | 0.9564 | 0.9917 |
| Examination | 7,8 | 0.9237 | 0.9737 |
| Trauma | 9,10 | 0.8595 | 0.9585 |
| Treatment | 5,6 | 0.8599 | 0.9604 |
| Total Sum: | | 4.5739 | 4.8803 |

We can see that if we keep increasing the staff, the objective function will keep growing. That means that we have achieved the optimal level of staff required that best fulfil FirstTreatment waiting standards.

Computation using MATLAB:

Graphical user interface, application

Description automatically generated