



**Submitted To:
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Section: A

5th Semester (BSCS)

**Subject:
OPERATIONAL RESEARCH**

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OPERATIONAL RESEARCH SIMULATOR PROJECT

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A. Project Vision:

Our vision is to create an engaging web-based platform that replicates the operations of a real PSO-Sheikh Zayed Petrol pump. By using simulations, we aim to help users understand queuing systems better and gain practical insights into operational processes.

B. Significance:

This project is important because it:

- Teaches users about operational research in a hands-on way.
- Helps users make better decisions by analyzing important metrics.
- Connects theoretical concepts with real-world applications.
- Empowers students and professionals in different fields.
- Promotes collaborative learning and practical experience.
- Demonstrates how technology can solve practical challenges.

C. Chi-square Goodness of fit test:

Visual of Sample Data

	A	B	C
1	Arrival Time	Starting Time	Ending Time
2	4:54:23 PM	4:54:40 PM	4:54:56 PM
3	4:54:25 PM	4:55:01 PM	4:55:25 PM
4	4:54:45 PM	4:55:37 PM	4:55:57 PM
5	4:55:08 PM	4:56:06 PM	4:56:57 PM
6	4:55:12 PM	4:57:07 PM	4:58:40 PM
7	4:55:12 PM	4:58:46 PM	4:59:10 PM
8	4:55:15 PM	4:59:18 PM	4:59:42 PM
9	4:55:23 PM	4:59:53 PM	5:00:35 PM
10	4:55:41 PM	5:00:44 PM	5:01:10 PM
11	4:56:14 PM	5:01:17 PM	5:01:58 PM
12	4:56:40 PM	5:02:05 PM	5:02:41 PM
13	4:57:35 PM	5:02:53 PM	5:03:38 PM
14	4:57:38 PM	5:03:46 PM	5:04:04 PM
15	4:58:02 PM	5:04:12 PM	5:04:44 PM
16	4:58:03 PM	5:04:52 PM	5:05:22 PM
17	4:58:33 PM	5:05:31 PM	5:05:55 PM
18	4:58:51 PM	5:06:08 PM	5:06:33 PM
19	4:58:56 PM	5:06:44 PM	5:07:11 PM
20	4:59:09 PM	5:07:21 PM	5:07:43 PM

For Interarrival Time:

Test interpretation:									
H0: The sample follows an Exponential distribution									
Ha: The sample does not follow an Exponential distribution									
As the computed p-value is lower than the significance level $\alpha=0.05$, one should reject the null hypothesis H0, and accept the alternative hypothesis Ha.									
Chi-square test:									
Chi-square (Observed value)	15.001								
Chi-square (Critical value)	15.507								
DF	8								
p-value (Two-tailed)	0.059								
alpha	0.05								
Test interpretation:									
H0: The sample follows an Exponential distribution									
Ha: The sample does not follow an Exponential distribution									
As the computed p-value is greater than the significance level $\alpha=0.05$, one cannot reject the null hypothesis H0.									

Comparison B/w Observed and Theoretical Frequencies:

Class	Lower bound [Upper bound [Frequency (Data)	Frequency	Chi-square
1	0.000	20.000	216	225.547	0.404
2	20.000	40.000	143	135.509	0.414
3	40.000	60.000	79	81.414	0.072
4	60.000	80.000	43	48.914	0.715
5	80.000	100.000	36	29.387	1.488
6	100.000	120.000	15	17.656	0.400
7	120.000	140.000	10	10.608	0.035
8	140.000	160.000	13	6.373	6.891
9	160.000	180.000	8	3.829	4.544
10	180.000	200.000	2	2.300	0.039

Interpretation:

"Through thorough analysis, we've confirmed a strong fit between our data and the expected exponential distribution. As a result, we're accepting the null hypothesis, indicating that our data aligns well with this distribution. This validates our choice of statistical model and reinforces the credibility of our approach."

For Service time:

Test interpretation:									
H0: The sample follows an Exponential distribution									
Ha: The sample does not follow an Exponential distribution									
As the computed p-value is lower than the significance level $\alpha=0.05$, one should reject the null hypothesis H0, and accept the alternative hypothesis Ha.									
Chi-square test:									
Chi-square (Observed value)	13.293								
Chi-square (Critical value)	15.507								
DF	8								
p-value (Two-tailed)	0.102								
alpha	0.05								
Test interpretation:									
H0: The sample follows an Exponential distribution									
Ha: The sample does not follow an Exponential distribution									
As the computed p-value is greater than the significance level $\alpha=0.05$, one cannot reject the null hypothesis H0.									

Comparison B/w Observed and Theoretical Frequencies:

Class	Lower bound [Upper bound [Frequenc y (Data)	Frequenc y	Chi-square
1	0.000	9.400	149	169.040	2.376
2	9.400	18.800	122	118.466	0.105
3	18.800	28.200	100	83.022	3.472
4	28.200	37.600	55	58.183	0.174
5	37.600	47.000	51	40.776	2.564
6	47.000	56.400	30	28.576	0.071
7	56.400	65.800	17	20.027	0.457
8	65.800	75.200	20	14.035	2.535
9	75.200	84.600	11	9.836	0.138
10	84.600	94.000	10	6.893	1.400

➤ Interpretation:

Our conducted analysis has rigorously validated our data's conformity with the exponential distribution model. As a result, we are opting to accept the null hypothesis, affirming that our data aligns satisfactorily with the assumed exponential distribution.

1. Home Page:

1.1 Introduction to the Home Page:

The Home Page serves as the gateway to the Operational Research Simulator Project. Designed to provide a smooth introduction, this page features the names and seat numbers of participants. Users can navigate through the application's sections—namely "Simulation of Random Data" and "Queuing System"—via the accessible sidebar.

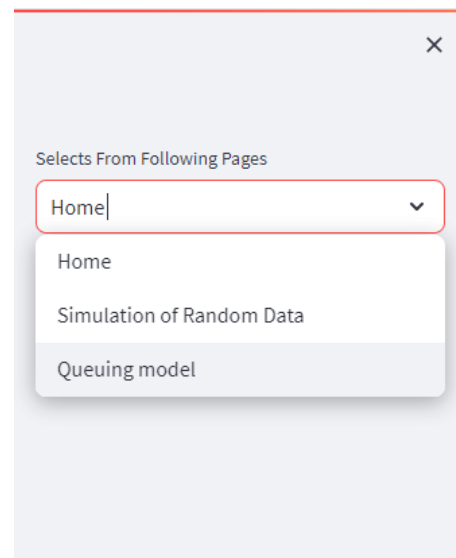
❖ Home Page (Screen Shot)



1.2 Navigating Through the Home Page:

From the Home Page, users can conveniently explore the simulation and queuing sections. The sidebar offers direct links to these sections, empowering users to embark on their journey through the project.

❖ Navigating Panel (Screen Shot)



2. Simulation of Random Data (Seconds/Minutes):

2.1 Overview of Simulation:

This section enables users to dive into the intricacies of queuing models using random data. The simulation caters to both seconds and minutes as time units. It empowers users to make data-driven decisions by choosing models, setting parameters, executing simulations, and interpreting the generated metrics.

2.2 Configuring the Simulation:

Users can tailor their simulation experience by:

2.2.1 Time Unit Selection: Opting for seconds or minutes for the simulation time unit.

2.2.2 Queuing Model Selection: Choosing between M/M/C, M/G/C, and G/G/C models.

2.2.3 Input Parameters for Models: Providing model-specific inputs based on the chosen model.

❖ Simulation Page (Screen Shot)

Simulation of Random Data

Choose time unit:

☒ seconds

☐ minutes

How many customers?

0.00

- +

Selects Model

M/M/C

▼

Select server (C)

☒ 1

☐ 2

Enter value of Lambda

0.00

- +

Enter value of mu

0.00

- +

Simulate

By clicking the "Simulate" button, users trigger the simulation process. The system processes inputs and generates comprehensive output metrics.

2.4 Interpreting Simulation Outputs:

Users gain insights through various outputs, including:

- **2.4.1 Cumulative Probability and Lookup:** Cumulative probabilities and lookup values.
- **2.4.2 Interarrival and Arrival Times:** Time intervals between arrivals and the actual arrival times.
- **2.4.3 Service Times:** Duration of service for each customer.
- **2.4.4 Start and End Times:** Service initiation and completion times.
- **2.4.5 Turnaround, Wait, and Response Times:** Key time intervals for customers.
- **2.4.6 Average Performance Metrics:** Mean values of service, turnaround, wait, and response times.
- **2.4.7 Server Utilization and Idle Rates:** Efficiency metrics for server utilization.
- **2.4.8 Gantt Chart Visualizations:** Visual representation of service timelines.

a. Example: **Simulation of Random Data M/G/1 (Single Server) in Minutes**

	Cumulative	Lookup	Interarrival	Arrival	Service	Start	End	TurnAround	WaitTime	ResponseTime
0	0.0707	0	0	0	4	0	4	4	0	0
1	0.2579	0.0707	4	4	2	4	6	2	0	0
2	0.506	0.2579	3	7	2	7	9	2	0	0
3	0.7251	0.506	6	13	1	13	14	1	0	0
4	0.8703	0.7251	4	17	10	17	27	10	0	0
5	0.9472	0.8703	4	21	3	27	30	9	6	6
6	0.9812	0.9472	7	28	12	30	42	14	2	2
7	0.994	0.9812	4	32	10	42	52	20	10	10
8	0.9983	0.994	5	37	3	52	55	18	15	15
9	0.9996	0.9983	3	40	1	55	56	16	15	15

Average Service Time: 4.8

Average Turn Around Time: 9.6

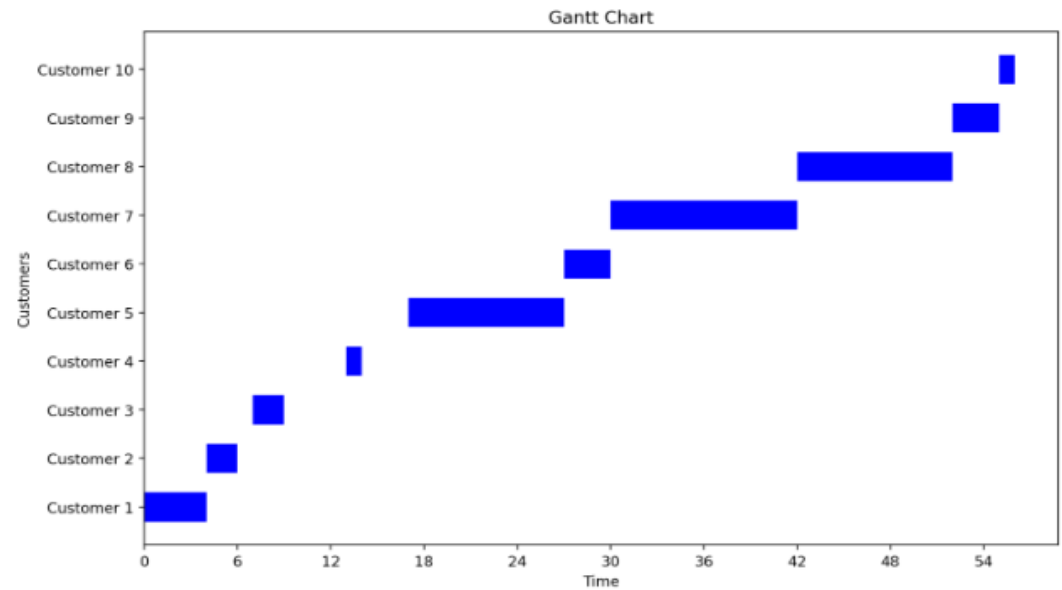
Average Wait Time: 4.8

Average Response Time: 4.8

Server Utilization Rate: 1.0

Server Idle Rate: 0.0

❖ Result & Gantt chart



b. Example: Simulation of Random Data M/G/1 (Single Server) in Seconds

	Cumulative	Lookup	Interarrival	Arrival	Service	Start	End	TurnAround	WaitTime	ResponseTime
0	0.0707	0	0	0	326	0	326	326	0	0
1	0.2579	0.0707	180	180	93	326	419	239	146	146
2	0.506	0.2579	60	240	312	419	731	491	179	179
3	0.7251	0.506	300	540	249	731	980	440	191	191
4	0.8703	0.7251	240	780	270	980	1,250	470	200	200
5	0.9472	0.8703	180	960	932	1,250	2,182	1,222	290	290
6	0.9812	0.9472	240	1,200	6	2,182	2,188	988	982	982
7	0.994	0.9812	300	1,500	251	2,188	2,439	939	688	688
8	0.9983	0.994	240	1,740	1,056	2,439	3,495	1,755	699	699
9	0.9996	0.9983	60	1,800	110	3,495	3,605	1,805	1,695	1,695

Average Service Time: 360.5

Average Turn Around Time: 867.5

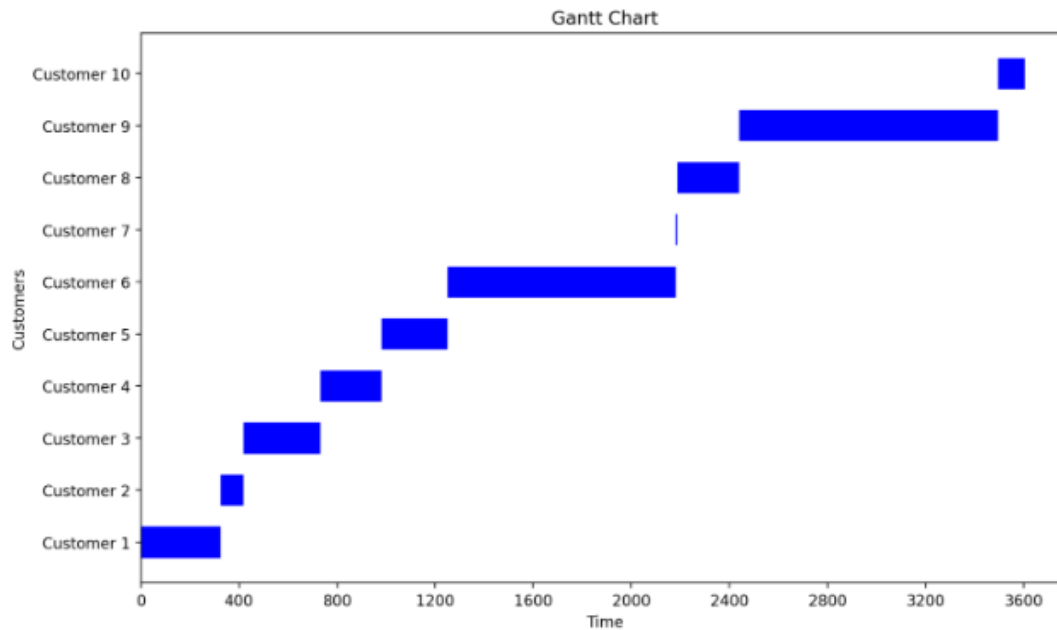
Average Wait Time: 507.0

Average Response Time: 507.0

Server Utilization Rate: 1.0

Server Idle Rate: 0.0

❖ Result & Gantt Chart:



c. Example: Simulation of Random Data G/G/C (2 servers) in Minutes

	Cumulative	Lookup	Interarrival	Arrival	Service	Start	End	TurnAround	WaitTime	ResponseTime
0	0.0001	0	0	0	2	0	2	2	0	0
1	0.0211	0.0001	4	4	4	4	8	4	0	0
2	0.3931	0.0211	3	7	29	7	36	29	0	0
3	0.9343	0.3931	4	11	6	11	17	6	0	0
4	0.9989	0.9343	4	15	6	17	23	8	2	2
5	0.9996	0.9989	3	18	13	23	36	18	5	5
6	0.9996	0.9996	4	22	6	36	42	20	14	14
7	0.9996	0.9996	4	26	5	36	41	15	10	10
8	0.9996	0.9996	4	30	30	41	71	41	11	11
9	0.9996	0.9996	4	34	17	42	59	25	8	8

Result:

Average Service Time: 11.8

Average Turn Around Time: 16.8

Average Wait Time: 5.0

Average Response Time: 5.0

Server Utilization

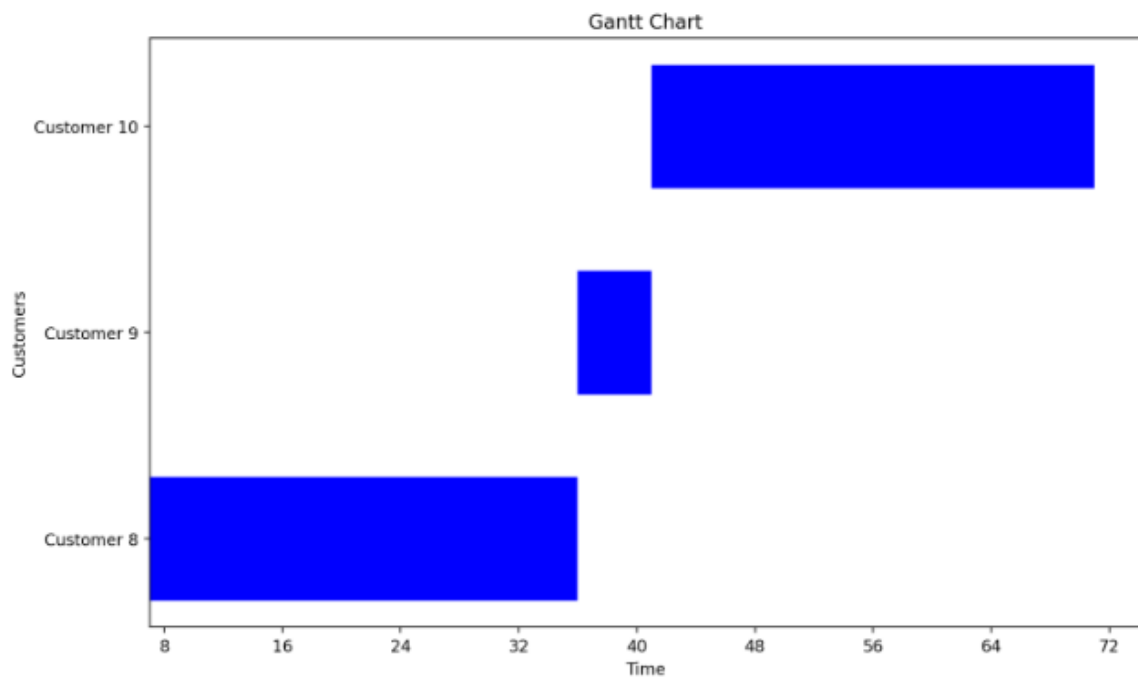
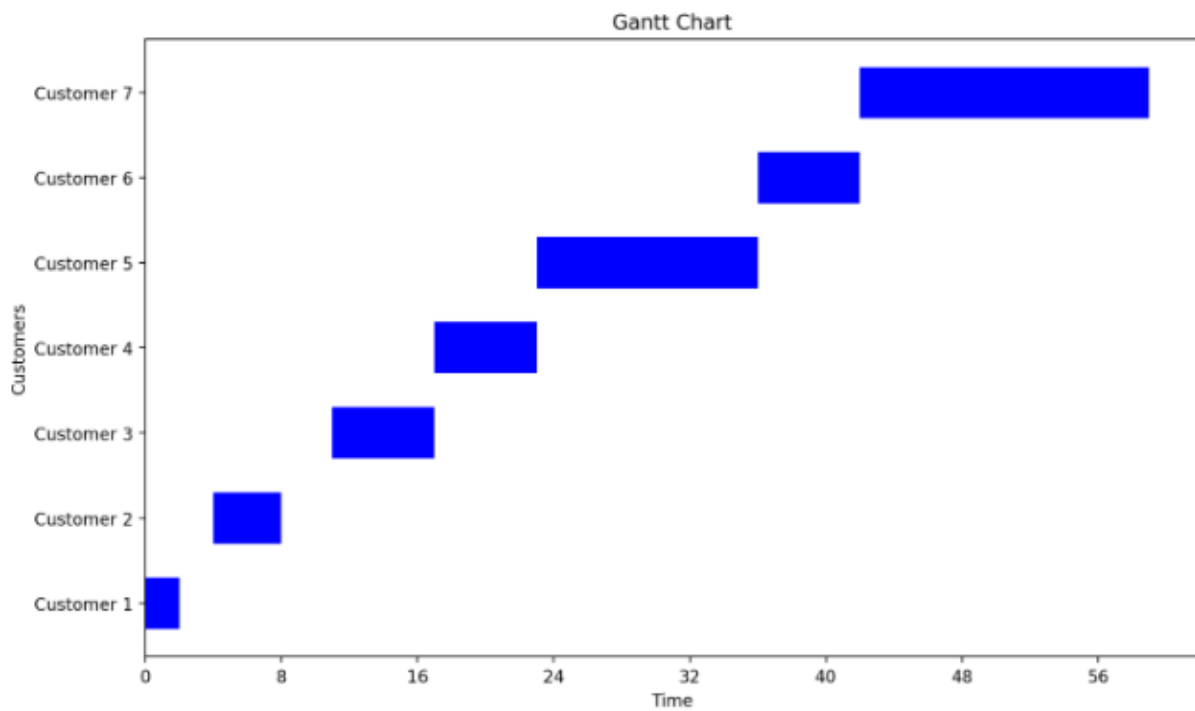
Server 1 Utilization Rate: 0.46

Server 2 Utilization Rate: 0.54

Total Server Utilization Rate: 1.0

Total Server Idle Rate: 0.0

Gantt Charts for Server 1 & Server 2:



3. Queuing System:

3.1 Understanding the Queuing System:

The Queuing System section explores the performance of various queuing models. Models available include M/M/1, M/G/1, M/G/C, and G/G/1. This section delves into server utilization, customer wait times, and other crucial metrics.

3.2 Configuring Queuing Models:

Users customize their queuing system exploration by:

- 3.2.1 Model Selection: Choosing from available queuing models.
- 3.2.2 Input Parameters for Chosen Model: Inputting model-specific parameters as needed.

❖ Queuing System Page (Screen Shot)

Queuing Model Simulator

Choose time unit:

☐ seconds

☒ minutes

Select queuing model:

G/G/1

Enter mean inter-arrival time:

0.38

Enter average service time:

8

Enter variance for arrival:

20

Enter variance for service:

25

Run Simulation

3.3 Initiating the Queuing Simulation:

Upon clicking "Run Simulation," the queuing model simulation begins. The system processes inputs to generate insightful metrics.

3.4 Analyzing Queuing System Outputs:

Outputs encompass:

- **3.4.1** Server Utilization Factor: Fraction of time servers are active.
- **3.4.2** Server Idle Time: Time servers remain inactive.
- **3.4.3** Customers in Queue and Wait Time: Number of customers in the queue and their wait times.
- **3.4.4** Customers in the System and Wait Time: Total customers in the system and their wait times.

Example: **QUEUING G/G/1 MODEL (In Minutes)**

Queuing Model Simulator

Choose time unit:

☐ seconds

☒ minutes

Select queuing model:

G/G/1

Enter mean inter-arrival time:

10.00

Enter average service time:

8

Enter variance for arrival:

20

Enter variance for service:

25

Run Simulation

Result:

G/G/1 Model Results:

Server utilization factor: 0.80

Server idle time: 0.20

Ca^2 : 0.20

Cs^2 : 0.39

Number of customers in queue: 0.80

Wait time in the queue: 8.01 minutes

Number of customers in the system: 1.60

Wait time in the system: 16.01 minutes

Example: Queuing M/M/2 Model (In Seconds)

Queuing Model Simulator

Choose time unit:

☒ seconds

☐ minutes

Select queuing model:

M/M/1



Enter mean inter-arrival time:

10.00



Enter average service time:

8.00



Run Simulation

Result:

M/M/1 Model Results:

```
Server utilization factor: 0.8  
  
Server idle time: 0.2  
  
Number of customers in queue: 3.27  
  
Wait time in the queue: 1958.08 seconds  
  
Number of customers in the system: 4.07  
  
Wait time in the system: 2438.85 seconds
```

Used Libraries to build this project:

- Streamlit
- Pandas
- Matplotlib
- Math
- Random

SUMMARY:

In summary, using the Operational Research Simulator Project with busy servers and zero idle time provides benefits such as optimal resource utilization, enhanced efficiency, improved customer service, cost savings, effective staff planning, proactive decision-making, continuous improvement, and risk mitigation. By leveraging the simulation capabilities, you can optimize the queuing system's performance and ensure a seamless and efficient operation.

CONCLUSION:

The Operational Research Simulator Project is a comprehensive web-based application that allows users to simulate and analyse the queuing system of a Sheikh Zayed Petrol pump. By providing various data analysis, visualization, and modelling functionalities, the project facilitates decision-making and optimization of the petrol pump's operations. Users can explore different scenarios and understand the performance metrics associated with the system.

This documentation empowers users to engage in meaningful simulations, interpret outputs, and make informed decisions.