In [ ]:

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#Problem 1: The length of a queue during a 30 minute period is 3 for the first 5 minutes,
# next 10 minutes, 2 for the next 6 minutes, and 3 for the last 9 minutes. What is the ave
# queue length during this time?

# Queue length and time (minutes)
queue_length = [3, 4, 2, 3]
time_minutes = [5, 10, 6, 9]
#Matrix results in [15, 40, 12, 27]
# Compute weighted average
sum_of_time = sum(q * t for q, t in zip(queue_length, time_minutes))
total_time = sum(time_minutes)

average_queue_length = sum_of_time / total_time
average_queue_length
#equation equals 94/30
```

Out[ ]:

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3.1333333333333333
```

Problem 2: Compute this problem manually without the aid of a simulation tool. A Navy helicopter mechanic starts his shift and services incoming helicopters at the following inter arrival times in hours:

[0, 1.4, 2.1, 1.9, 0.2, 1.5]

Thus the first pilot arrives at the very beginning of his shift. The respective helicopter service times in hours are:

[2.2, 1.2, .3, 2.8, .2, 1.8]

Calculate the minimum and maximum queue length for this period, the total queue time (total time spent in queue for all pilots), the average waiting time in queue, the total idle time for the mechanic, and the resource utilization for the mechanic. Show all your work

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Data organization

arrival times in hours: [0, 1.4, 2.1, 1.9, 0.2, 1.5]

Total Time [0 + 1.4 + 2.1 + 1.9 + 0.2 + 1.5] = 7.1

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Service times in hours are: [2.2, 1.2, .3, 2.8, .2, 1.8]

Total Time (2.2 + 1.2 + .3 + 2.8 + 0.2 + 1.8) = 8.5

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Arrival [0.0, 1.4, 3.5, 5.4, 5.6, 7.1]

–

Service Time [2.2, 1.2, .3, 2.8, .2, 1.8]

–

Service Start [0.0, 2.2, 3.5, 5.4, 8.2, 8.4]

–

Service Finish [2.2, 3.4, 3.8, 8.2, 8.4, 10.2]

*Service starts at max(arrival time, previous service finish)

*Finish = start + service time

Wait Time [0, .8, 0, 0, 2.6, 1.3]

At 1.4, Pilot 2 arrives while Pilot 1 is still in service → queue = 1

At 5.6, Pilot 5 arrives while Pilot 4 is in service → queue = 1

At 7.1, Pilot 6 arrives while Pilot 4 is still in service and Pilot 5 is already waiting → queue = 2

Minimum queue length: 0

Maximum queue length: 2

Total queue time: 0 + .8 + 0 + 0 + 2.6 + 1.3 = 4.7

Average 4.7/6=.783

Mechanic idle time

From 3.4 to 3.5 = 0.1

From 3.8 to 5.4 = 1.6

Total idle time = 1.7

Resource Utilization

Total Service Time: 2.2 + 1.2 + 0.3 + 2.8 + 0.2 + 1.8 = 8.5

Observed Time: 10.2 - 0 = 10.2

Utilization: 8.5 / 10.2 = .83 (83%)

In [26]:

```
#Below is another depiction of the class example for the Navy cargo ship maintenance
#facility scenario. This is for the single facility configuration and all time units are i

#1)What is the average waiting time for the ships that need service?
#2)Calculate the 20-day resource utilization of the single facility using fractional days.
#facility is open and staffed 24 hours each day available for service.



#Ship = [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20]
#Interarrival_Time = [0, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1]
#Service_Time = [2.5, 0, 2, 0, 3, 1.5, 0, 2, 1, 0, 0, 0, 2, 0, 0, .5, 0, 1.5, 3, 0]
#Arrival_Time = [0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]
#Service_Start = [0, 0, 2.5, 0, 4.5, 7.5, 0, 9, 11, 0, 0, 0, 12, 0, 0, 15, 0, 17, 18.5, 0,
#Service_End = [2.5, 0, 4.5, 0, 7.5, 9, 0, 11, 12, 0, 0, 0, 14, 0, 0, 15.5, 0, 18.5, 21.5,
import pandas as pd
#Ships that need service
```

```
data = {
"Ship1" : [1, 3, 5, 6, 8, 9, 13, 16, 18, 19],
"Interarrival_Time1" : [0, 1, 1, 1, 1, 1, 1, 1, 1, 1],
"Service_Time1" : [2.5, 2, 3, 1.5, 2, 1, 2, .5, 1.5, 3],
"Arrival_Time1" : [0, 2, 4, 5, 7, 8, 12, 15, 17, 18],
"Service_Start1" : [0, 2.5, 4.5, 7.5, 9, 11, 12, 15, 17, 18.5],
"Service_End1" : [2.5, 4.5, 7.5, 9, 11, 12, 14, 15.5, 18.5, 21.5]
}
df = pd.DataFrame(data)
# ----------------------------
# Waiting time calculations
# ----------------------------
#Wait time = Service start - Arrival
df["Wait_Time"] = df["Service_Start1"] - df["Arrival_Time1"]

total_queue_time = df["Wait_Time"].sum()
average_queue_time = df["Wait_Time"].mean()

# ----------------------------
# Resource utilization (20-day window)
# ----------------------------
Busy_time = df["Service_Time1"].sum()
Available_time = 20 #20 days, 24/7

Resource_use = Busy_time/Available_time

# ----------------------------
# Display results
# ----------------------------
df
print(f"Average waiting time: {average_queue_time:.2f} days")
print(f"20 day Resource utilization: {Resource_use:.2%}")
```

```
Average waiting time: 0.90 days
20 day Resource utilization: 95.00%
```

In Problem 3, how might the resource utilization change for the first facility when a second facility is added? In this case ships will be serviced by the second facility when the first is busy. Assume the same inputs for ship arrivals and service durations.

A. it will be the same

B. it will increase

C. it will decrease

D. it cannot be determined

answer: Adding a second facility means some ships are serviced by the second one instead of waiting for the first, making the first facility reduce it's overall busy time.

Answer C