


by Eng. Zena Qasem

The University of Jordan الجامعة الاردنية

| Form: Paper-Based Questions Cover Sheet | | |
|---|---|---|
| | Policy Number | SUJ-02-01-04A |
| | Issue Number and Date | 2/3/24/2022/2963 5/12/2022 |
| | Number and Date of Revision or Modification | |
| | Deans Council Approval Decision Number | 3/ 4/24/2023 |
| | The Date of the Deans Council Approval Decision | 23/01/2023 |
| | Number of Pages | 02 |

| | | | | | |
|---|---|---|---|---|---|
| School | Engineering | | | Department | IE |
| Course Name | Simulation | | | Course No. | 0936553 |
| Academic Year | 2024/25 | Semester | 2nd | Exam Type | MID |
| Exam Date | 5/11/2025 | | | Exam Time | 2:30-3:30 |

| | | | |
|---|---|---|---|
| الرقم الجامعي: 0215522 | اسم الطالب (باللغة العربية): محمد عبد القادر أحمد حسني | | |
| الرقم المتسلسل: | وقت المحاضرة: | رقم الشعبة: | اسم المدرس: أ.د محمود برغش |

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**Important Instructions**

1. This is a closed (open) book exam; all related material must be placed away from your desk.
2. Cell phone use is prohibited for any purpose: Your cell phone must be turned off and placed off the desk. Cell phones may not be accessed during the exam. Failure to comply may be treated as a violation of the Honor Code.
3. Headphones of any kind are not permitted.
4. This exam is (__50__) minutes long.
5. Make sure that you have ( 6 ) pages including this page.
6. This exam has ( 5 ) essay questions. Read each question carefully before answering.
7. Calculators can be used and can (*not*) be shared.
8. When you finish, you must:
9. Check that you have written your information in the spaces provided.
10. Give the exam package (all papers) to the proctor before you leave.

**For Teacher's Use Only**

| No. | ILO | SO | DL | Mark | Weight |
|---|---|---|---|---|---|
| 1 | | | 2 | 6 | 6 |
| 2 | | | 2 | 4 | 4 |
| 3 | | | 2 | 6 | 6 |
| 4 | | | 2 | 6 | 7 |
| 5 | | | 2 | 7 | 7 |

*KPI: Key Performance Indicator, ILO: Intended Learning Outcomes, SO: Student Outcomes, DL: Difficulty Level (1. Easy, 2. Average, 3. Hard, 4. Very Hard).*

29 30

**For Proctor's Remarks**

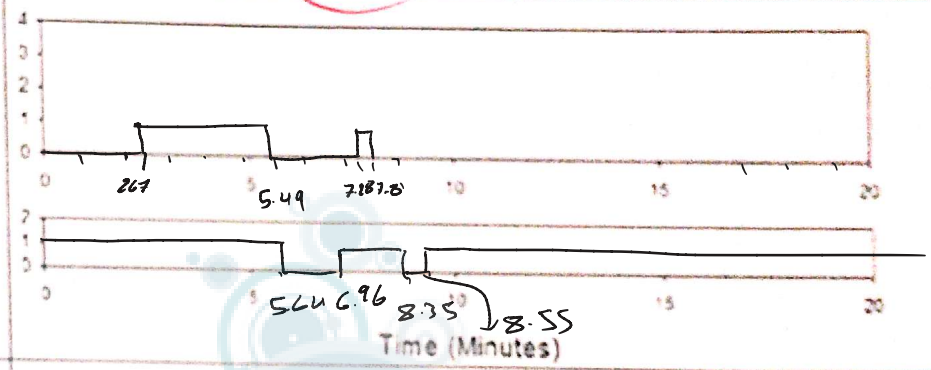
CamScanner

Q1) perform simulation by hand for the single machine single queue system with the following characteristics and draw the figures(4 points)

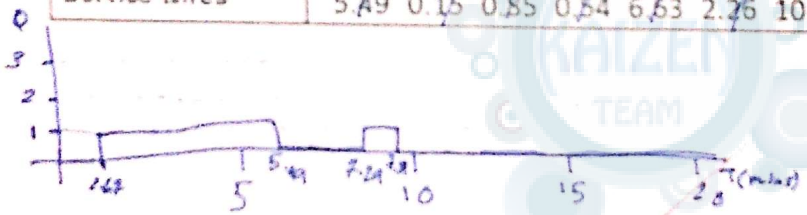
| System | Clock | B(t) | Q(t) | Arrival times of custs. in queue | Event calendar |
|---|---|---|---|---|---|
| Number of completed waiting times in queue | Total of waiting times in queue | | Area under Q(t) | | Area under B(t) |

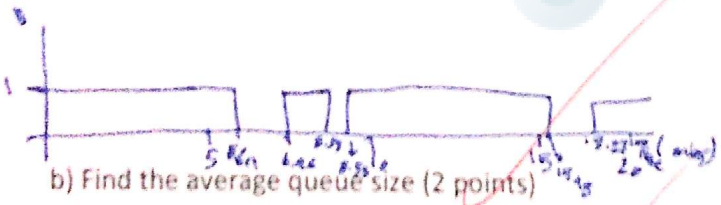
Q(t) graph

B(t) graph




| | |
|---|---|
| Interarrival times | 2.67 4.29 0.33 1.26 9.72 2.32 3.05 5.15 4.93 7.45 9.34 7.91 4.66 |
| Service times | 5.49 0.15 0.85 0.54 6.63 2.26 10.3 5.59 0.44 1.34 1.73 1.72 15.4 |





b) Find the average queue size (2 points)

| Arr | Dep | T | Q |
|---|---|---|---|
| 0 | 5.49 | 5.49 | 0 |
| 2.67 | 5.64 | 2.97 | 2.82 |
| 6.96 | 7.81 | 0.85 | 0 |
| 7.29 | 8.35 | 1.06 | 0.52 |
| 8.55 | 15.18 | 6.63 | 0 |
| 18.27 | 20.53 X | — | 0 |
| 20.59 | | | |

$$\frac{(5.49-2.67)+(7.81-7.29)}{20} = 0.167 \text{ /min.}$$

avg Q size:

$$\frac{-2.67+5.49-7.28+7.81}{20} = \frac{3.35}{20} = 0.1675 \text{ min}$$

CamScanner

Time (Minutes)

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Interarrival times | 2.67 | 4.29 | 0.33 | 1.26 | 9.72 | 2.32 | 3.05 | 5.15 | 4.93 | 7.45 | 9.34 | 7.91 | 4.66 |
| Service times | 5.49 | 0.15 | 0.85 | 0.54 | 6.63 | 2.26 | 10.3 | 5.59 | 0.44 | 1.34 | 1.73 | 1.72 | 15.4 |

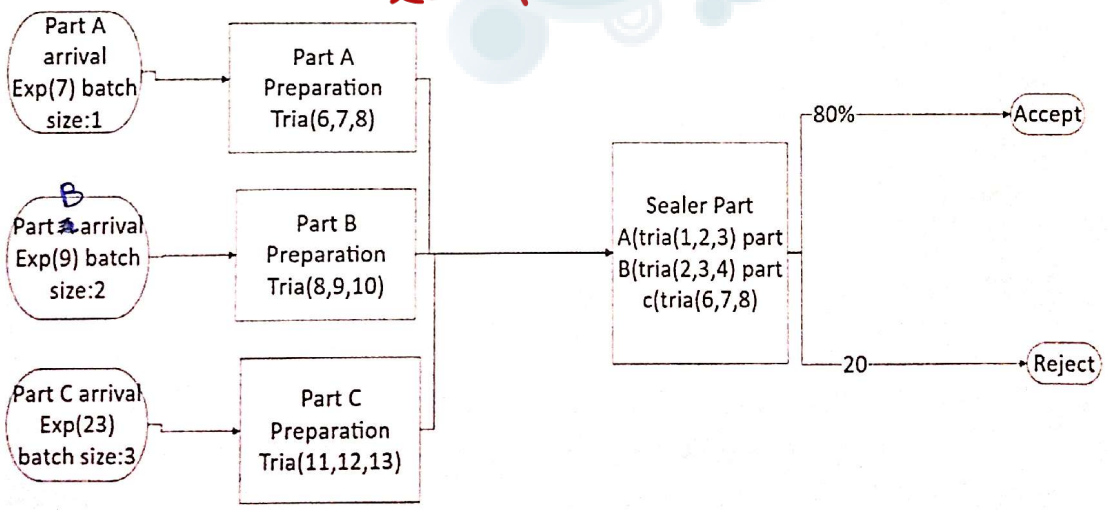
| Entity # | Time in Arr | Time leave Queue | Time in machine | Time Leave machine def | Queue time Q | Time in system T |
|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 5.49 | 0 | 5.49 |
| 2.67 | 5.49 | 5.49 | | 5.64 | 2.82 | 2.97 |
| 6.96 | 6.96 | | | 7.81 | 0 | 0.85 |
| 7.29 | 7.81 | | | 8.35 | -0.52 | 1.06 |
| 8.55 | 8.55 | | | 15.18 | 0 | 6.63 |
| 18.27 | 18.27 | | | 20.53X | 0 | — |
| 20.59 | | | | | | |

| Arr | Dep | T | Q |
|---|---|---|---|
| 0 | 5.49 | | |
| 2.67 | 5.64 | | |
| 6.96 | 7.81 | | |
| 7.29 | 8.35 | | |
| 8.55 | 15.18 | | |
| 18.27 | 20.53X | | |
| 20.59 | | | |

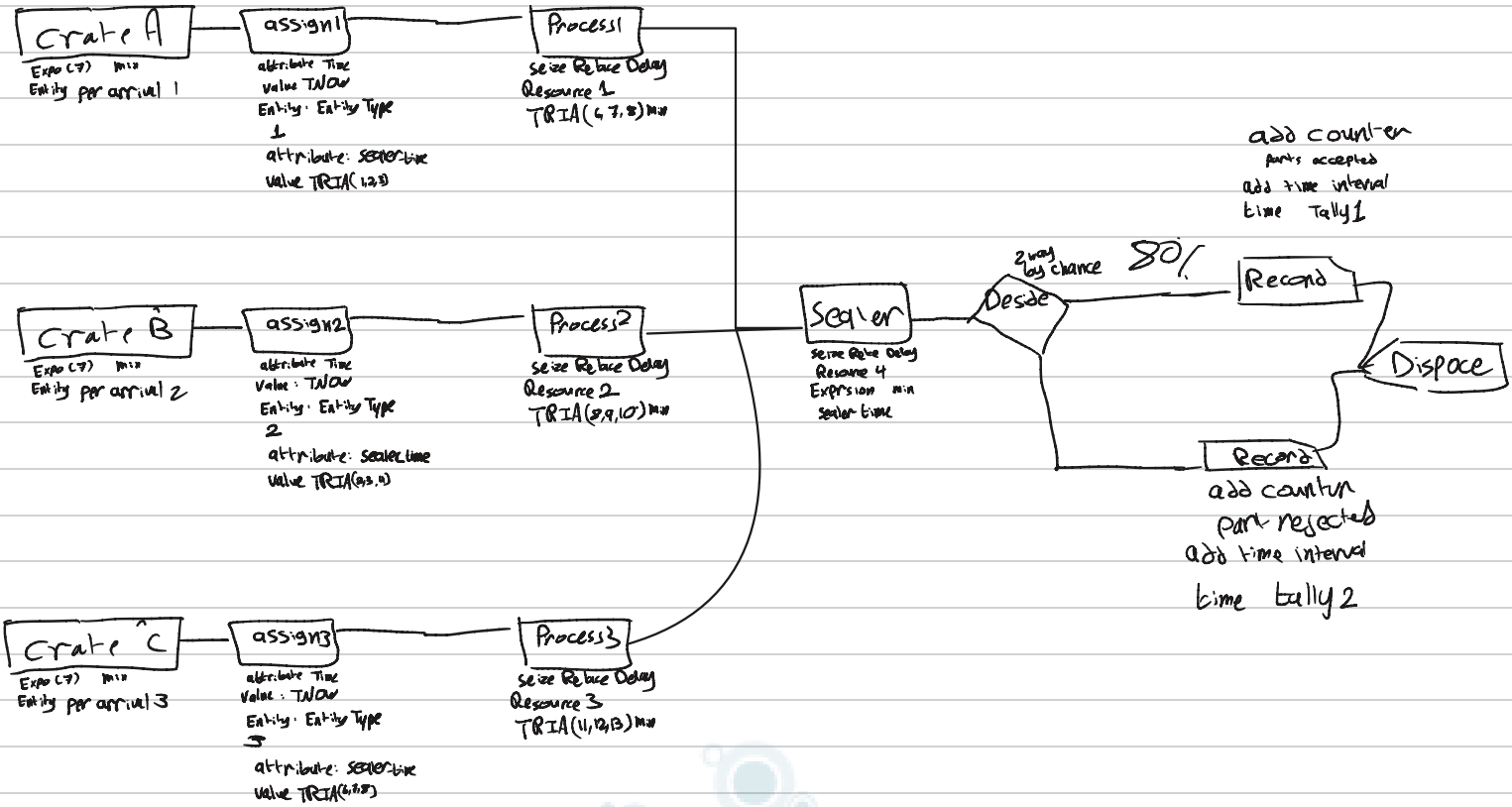
Q2) Find in the meaning of the following symbols in ARENA discrete event simulation (4 points)

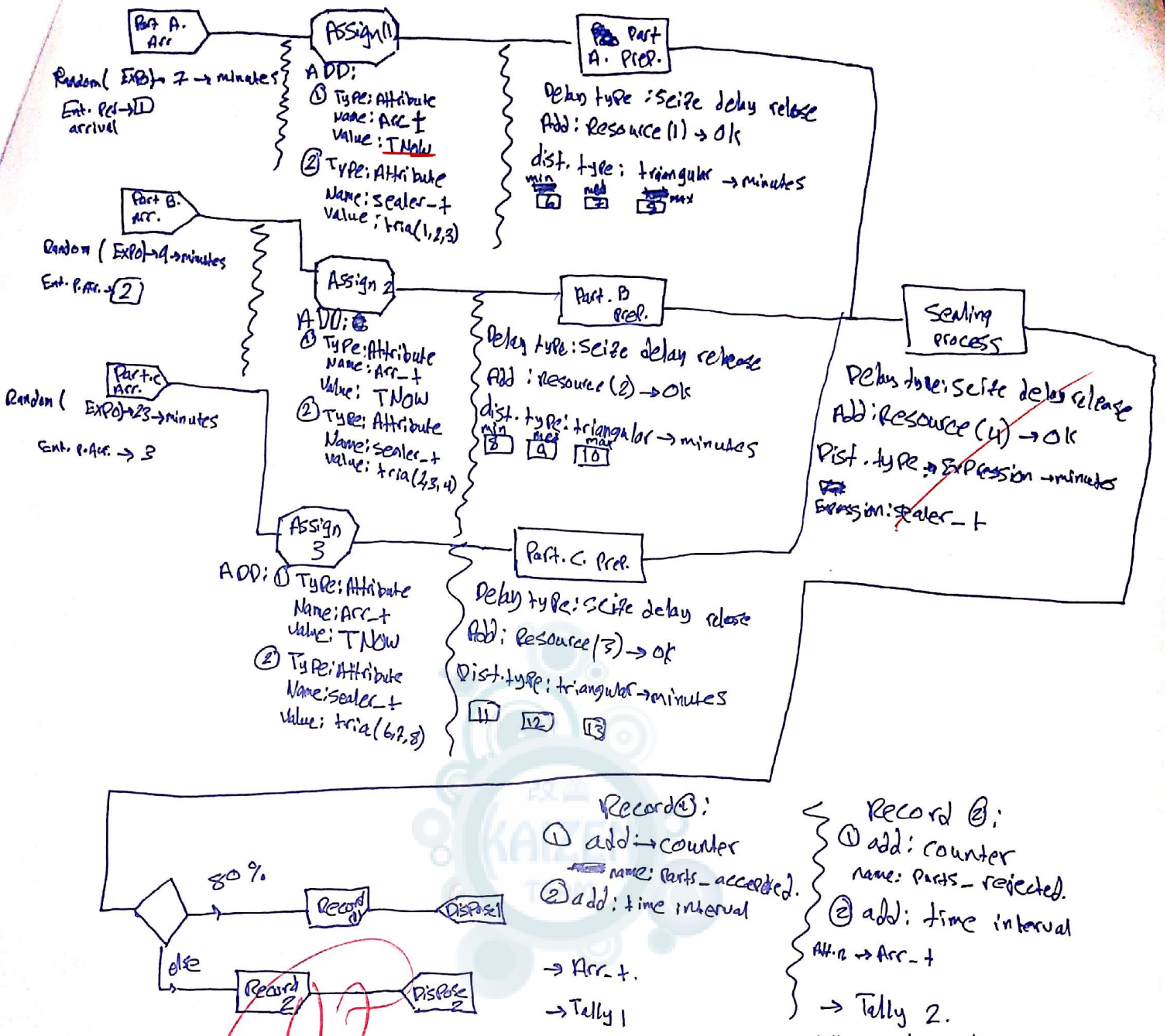
| Symbol | meaning |
|---|---|
| ▶ | Go, to run the system |
| Warm-up Period 00 | set the length of warm-up period, which the system won't take the stat in that period (beginning) |
| Number of Replications: 1 | How much repetitive times the system will run |
| D | add a distance animation |

Q3) a) show the arena simulation for the system shown in the following figure. Add statistical collection for the number of parts produced and the time in system




Three parts arrive a, b, c then they are prepared , the sealer time for each is shown in the figure. (6 points)


Crate A
Expo (7) min
Entity per arrival 1
assign1
attribute Time
Value TNOW
Entity · Entity Type
1
attribute: SealerTime
Value TRIA(1,2,3)
Process1
seize Relase Delay
Resource 1
TRIA(6,7,8) min
Crate B
Expo (7) min
Entity per arrival 2
assign2
attribute Time
Value : TNOW
Entity · Entity Type
2
attribute: SealerTime
Value TRIA(9,9,9)
Process2
seize Relase Delay
Resource 2
TRIA(8,9,10) min
Crate C
Expo (7) min
Entity per arrival 3
assign3
attribute Time
Value : TNOW
Entity · Entity Type
3
attribute: SealerTime
Value TRIA(6,7,8)
Process3
seize Relase Delay
Resource 3
TRIA(11,12,13) min
Sealer
seize Relase Delay
Resource 4
Expression min
Sealer time
Decide
2 way by chance
80%
Record
add counter
parts accepted
add time interval
time Tally 1
Dispose
Record
add counter
part rejected
add time interval
time tally 2




Q4) The call center handles customer calls through a central number with 4 trunk lines and operates from 8 am to 4 pm. Calls arrive every 0.857 minutes on average (exponentially distributed). If all lines are busy, callers are lost. Callers choose between technical support (76%), sales (16%), or order status (8%), after a brief recording (0.2–0.9 min).

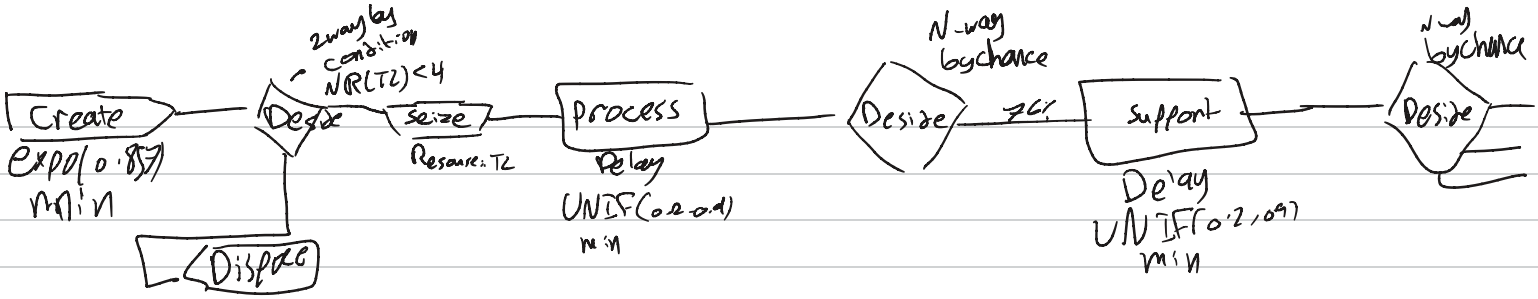
Technical support calls (UNIF(0.2, 0.9) min to select product) are handled by 8 specialists: 2 for product 1, 3 for product 2, and 3 for product 3. If none are available, calls queue with music. Service time is TRIA(4, 5, 17) minutes.

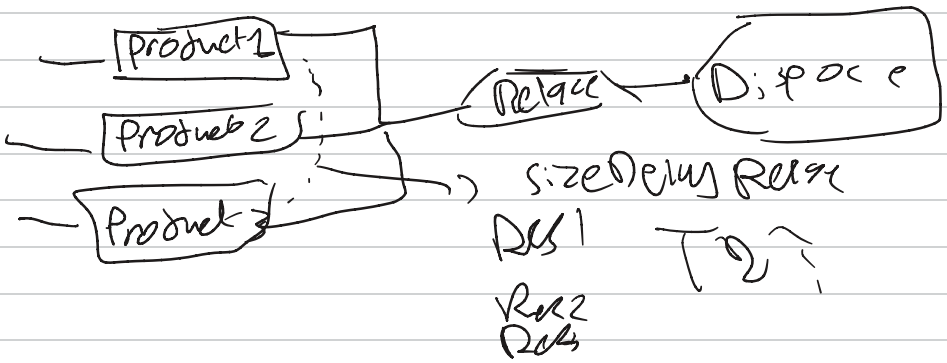
Sales calls are handled by 4 salespeople, or queue with music if unavailable. Sales calls last TRIA(4, 15, 45) minutes.

It turns out that there are six salespeople with the staggered daily schedules summarized as (number of people @ time period in minutes): 1@60, 3@60, 4@90, 5@60, 6@60, 5@90, 6@90, 5@30, 3@60, and 2@60.

Order-status calls are system-handled (TRIA(2, 3, 4) min); 15% request human help and are routed to sales staff but with lower priority than regular sales calls. These follow-up calls also take TRIA(2, 3, 4) minutes. Calls are answered as long as they enter before 6 pm. Model using arena (7 points)

CamScanner




Data Det

TR capcity 4

Res1 capcity 2

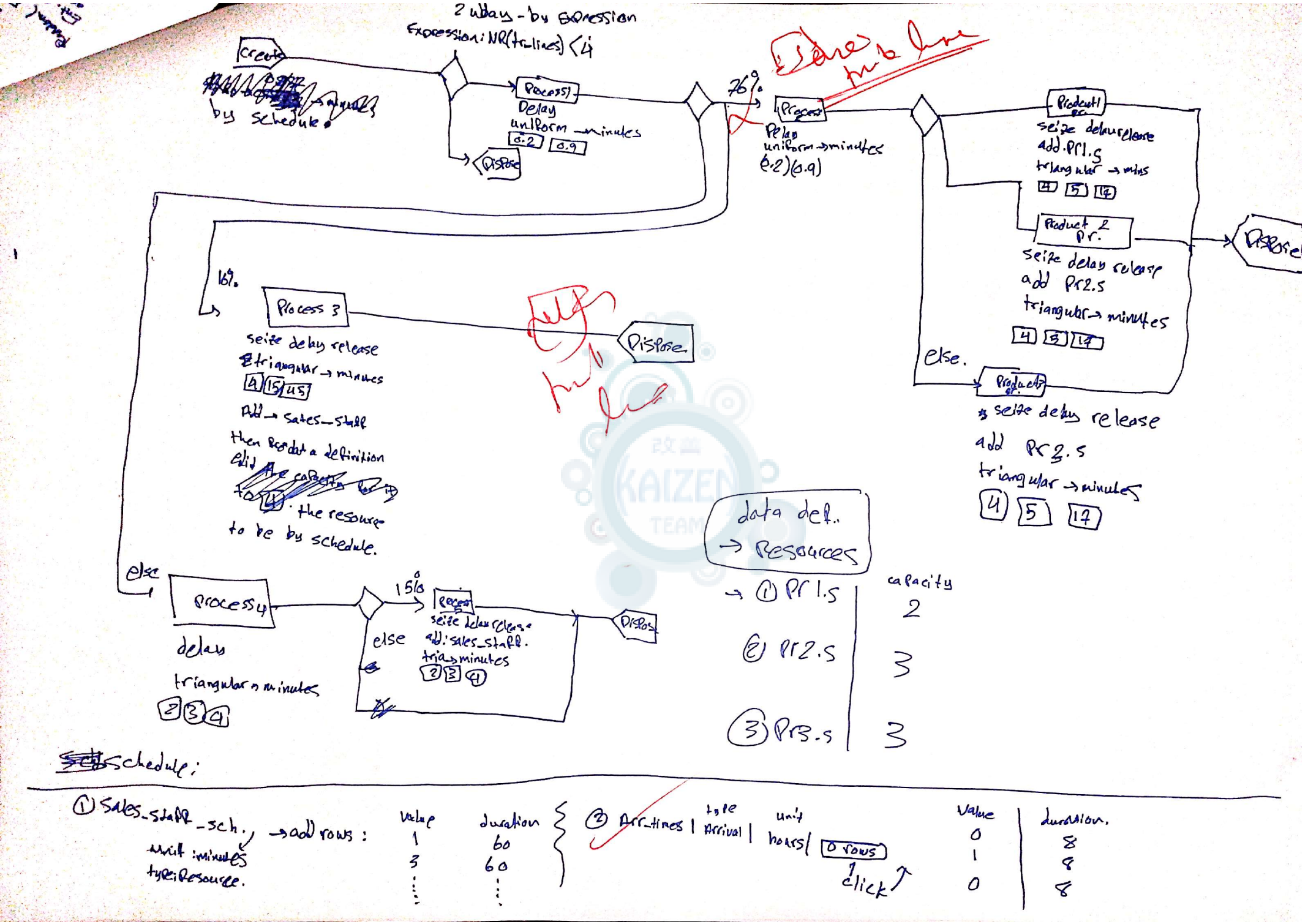
Res2

Res

set up:

Time and Data start: 8:00 Am 30-nov-2025

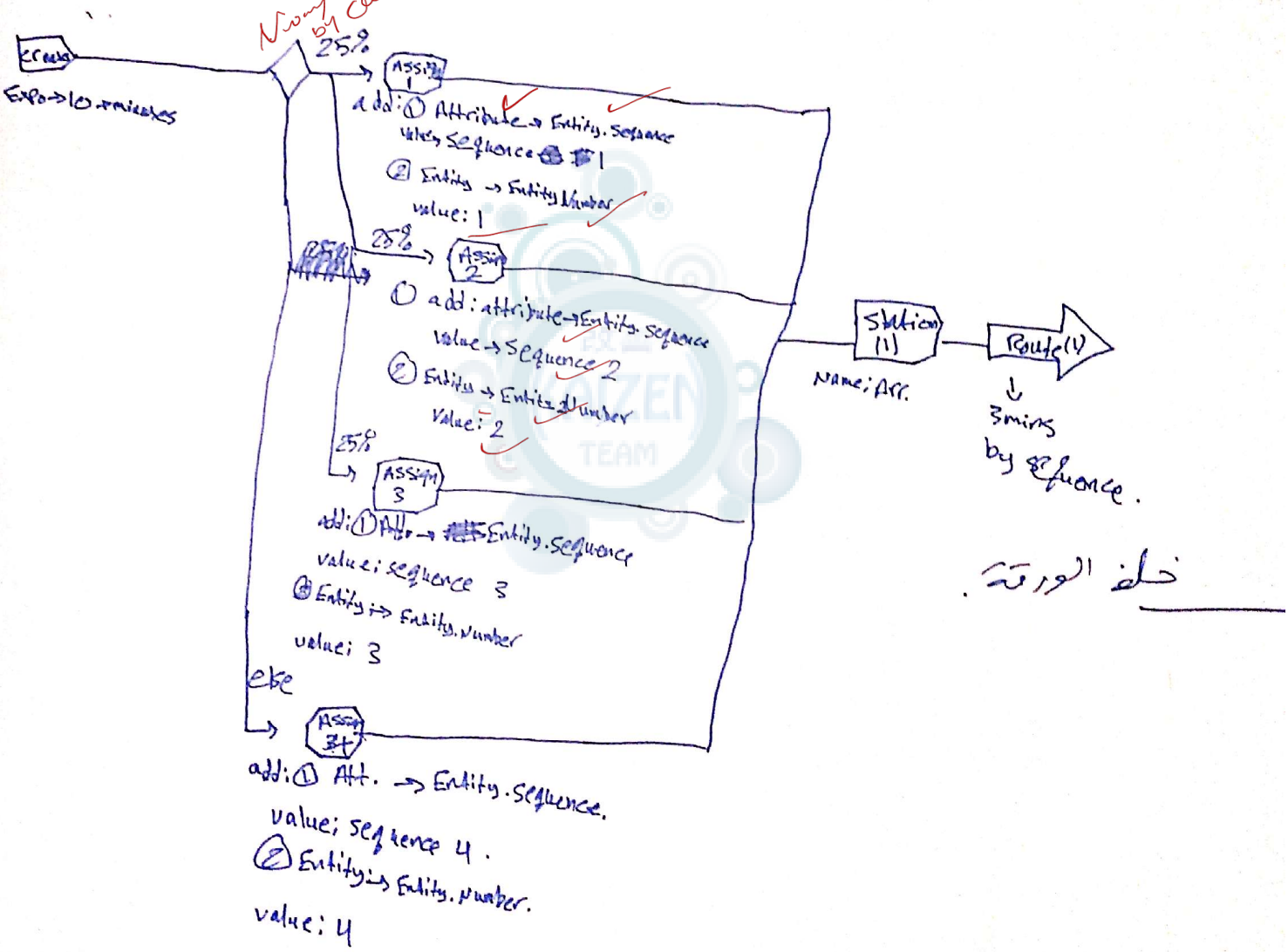
Hours per day: 8 hours Base units: minutes

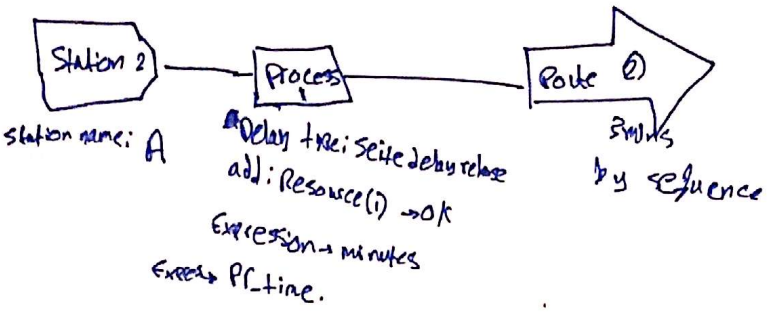

2 ways - by Expression
Expression: NR(trucks) < 4
Create
by schedule
Process1
Delay
uniform → minutes
0.2
0.9
Dispose
76%
Process 2
Delay
uniform → minutes
(0.2)(0.9)
else
Product1 pr.
seize delay release
add Pr1.s
triangular → mins
4
5
17
Product 2 pr.
seize delay release
add Pr2.s
triangular → minutes
4
5
17
Dispose
else.
Product3 pr.
seize delay release
add Pr2.s
triangular → minutes
4
5
17
16%
Process 3
seize delay release
triangular → minutes
4
15
45
Add → Sales_staff
then Product definition
Edit
to 4
the resource
to be by schedule.
Dispose
else
Process 4
delay
triangular → minutes
2
3
4
15%
Process 5
seize delay release
add: sales_staff.
tria → minutes
2
3
4
else
Dispose
data def.
→ Resources
capacity
① Pr1.s 2
② Pr2.s 3
③ Pr3.s 3
schedule:
① Sales_staff_sch.
→ add rows:
unit: minutes
type: Resource.
value
1
3
duration
60
60
② Arr_times
type
Arrival
unit
hours
0 rows
1 click
value
0
1
0
duration.
8
8
8

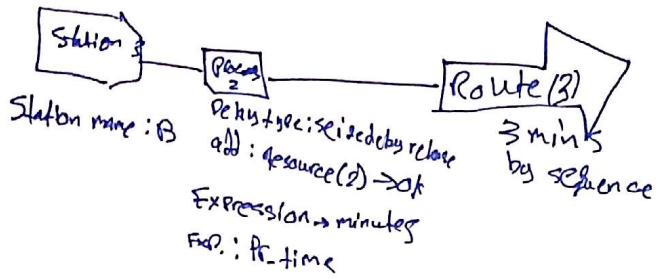
Q5) A part arrives every 10 minutes to a system having three workstations (A, B, and C), where each workstation has a single machine; the fi rst part arrives at time 0. There are four part types, each with equal probability of arriving. The process plans for the four part types are given here. The entries for the process times are the parameters for a triangular distribution (in minutes).

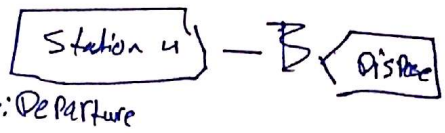
| Part Type | Workstation/ Process Time | Workstation/ Process Time | Workstation/ Process Time |
|---|---|---|---|
| Part 1 | A<br>5.5,9.5,13.5 | C<br>8.5,14.1,19.7 | |
| Part 2 | A<br>8.9,13.5,18.1 | B<br>9.15,21 | C<br>4.3,8.5,12.7 |
| Part 3 | A<br>8.4,12.15.6 | B<br>5.3,9.5,13.7 | |
| Part 4 | B<br>9.3,12.6,16.0 | C<br>8.6,11.4,14.2 | |

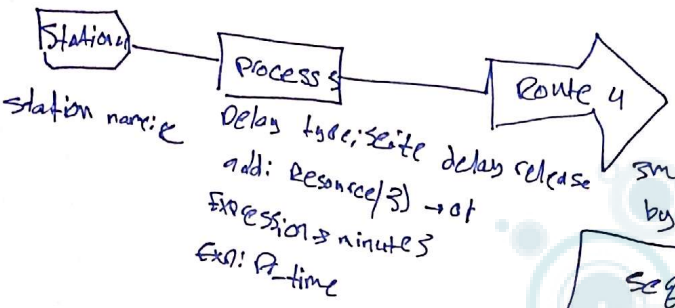
Assume that the transfer time between arrival and the first station, between all stations, and between the last station and the system exit is 3 minutes. Use the Sequence feature to direct the parts through the system and to assign the processing times at each station. Model using arena (7 points)






Data definition:

→ Sequences:

add 4 sequences:

sequence1:

Add 4 (rows):

| Station | Att. | Pr_time | tria(4.9, 13.5, 21.1) |
|---|---|---|---|
| A | | | |
| B | Att. | = | =(9, 15, 21) |
| C | | | |
| Departure | Att. | = | =(4.3, 8.5, 12.7) |

Sequence (2):

Add 3 (rows):

| Station | Att. | Pr_time | tria(8.4, 12, 15.1) |
|---|---|---|---|
| A | | | |
| B | Att. | Pr_time | =(5.3, 9.5, 12.2) |
| Departure | | | |

Sequence 3:

Add 3 rows:

Sequence 4

Add 3 rows:

| Station | Att. | Pr_time | tria(5.5, 9.5, 13.5) |
|---|---|---|---|
| A | | | |
| C | Attribute | Pr_time | tria(8.5, 14.7, 19.7) |
| Departure | | | |

| Station | Att. | Pr_time | tria(9.3, 12.6, 16) |
|---|---|---|---|
| B | | | |
| C | Att. | Pr_time | tria(8.6, 11.4, 14.2) |
| Departure | | | |

| Exam Information بيانات الامتحان | | | | | |
|---|---|---|---|---|---|
| الكلية والقسم School & Dept. | الصناعيه | | | العام الجامعي Academic year | 25\2024 |
| اسم المادة Course name | المحاكاه | | | الفصل الدراسي Semester | الصيفي |
| رقم المادة Course number | 0936553 | | | تاريخ الامتحان Exam date | 2025\11\30 |
| نوع الامتحان Exam type | ☐ أول/ثان 1st/2nd | ☐ منتصف الفصل Midterm | نهائي | وقت الامتحان Exam time | 11:00 9:00 |
| علامة الامتحان Exam Mark | 50 | | | مدة الامتحان Exam duration | 55 minutes |
| نوع الأسئلة Questions type | ☐ مقالي Open-ended | | | نوع ورقة الإجابة Answer sheet type | الاجابه حصرا بعد السوال في المكان المخصص للاجابه يمنع الكتابه خلف الورقه الا كمسوده وغير ملزم باحتساب ما هو خلف الورقه |
| الأدوات التي يحتاجها الامتحان Exam required tools | ☐ آلة حاسبة Calculator عاديه لا تخزن المعادلات ..... : | | | نوع قلم تدوين الإجابات Answering pen type | ☐ قلم رصاص Pencil ☐ قلم حبر (أزرق/ أسود) Pen (blue/ black) |

| Student Information بيانات الطالب | | | | |
|---|---|---|---|---|
| اسم الطالب باللغة العربية (إجباري) Student's name in Arabic* | [redacted] | | | |
| الرقم الجامعي (إجباري) Student's number* | [redacted] | رقم الشعبة Section no. | | وقت المحاضرة Lecture time |
| رقم الجلوس في المحاضرة Seat no. in lecture room | | رقم الجلوس في الامتحان Exam seat no. | | |

| Exam Instructions تعليمات الامتحان | |
|---|---|
| 1. Read the exam information carefully and adhere to it: question types, answer sheet format, pen type, necessary tools, total exam marks, and exam duration. | 1. قم بقراءة بيانات الامتحان بتمعن والتزم بها: نوع الأسئلة، ونوع ورقة الإجابة، ونوع القلم، والأدوات التي يحتاجها الامتحان، وعلامة الامتحان الكلية، ومدة الامتحان. |
| 2. Ensure that all your question pages are available. | 2. تحقق من توفر جميع صفحات الأسئلة لديك. |
| 3. Do not place any exam-related materials close to your seat. | 3. يمنع وضع المواد ذات الصلة بالامتحان قريبا من المقعد. |
| 4. Mobile phones are prohibited and must be completely turned off, not in airplane/silent mode. Follow the supervisors' instructions regarding phones. | 4. يحظر استخدام الهواتف النقالة ويتم إغلاقها بشكل تام وليس في وضع الطيران/الصامت، ويجب اتباع تعليمات المراقبين بشأن الهواتف. |
| 5. Use of headphones or any type of smart devices (visual/auditory/sensory) is prohibited. | 5. يحظر استخدام سماعات الرأس أو الأجهزة الذكية من أي نوع (البصرية/ السمعية/ الحسية). |
| 6. Do not use/bring additional papers for the exam; you will be provided with the necessary papers if required during the exam. | 6. يحظر استخدام/ إحضار أوراق إضافية للامتحان وسيتم تزويدك بالورق الذي تحتاجه إذا تطلب الامتحان ذلك. |

## Exam Supervisor's Notes ملاحظات مراقب الامتحان

| Question | Grade | Full | Question | Grade | Full |
|---|---|---|---|---|---|
| 1 | 5 | 5 | 4 | 1.5 | 5 |
| 2 | 5 | 6 | 5 | 4 | 5 |
| 3 | 5 | 5 | 6 | 4 | 4 |
| Total | 15 | | | 9.5 | |

24.5/30



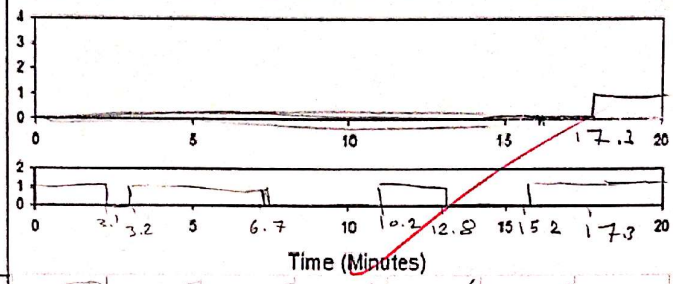
CamScanner

Q1) perform simulation by hand for the single machine single queue system with the following characteristics (4 points)

| System | Clock | B(t) | Q(t) | Arrival times of custs. in queue | Event calendar |
|---|---|---|---|---|---|
| Number of completed waiting times in queue | Total of waiting times in queue | Area under Q(t) | Area under B(t) | | |

Q(t) graph

B(t) graph




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Interarrival times | 3.2 | 7.0 | 5.0 | 2.1 | 7.3 | 5.8 | 17.1 | 10.8 |
| Service times | 3.1 | 3.5 | 2.6 | 8.5 | 0.1 | 1.3 | 29.0 | 3.3 |

| Entity # | Time in | Time leave Queue | Time in machine Arr # | Time Leave machine def | Queue time Q | Time in system T |
|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 3.1 | 0 | 3.1 |
| 2 | 3.2 | 3.2 | 3.2 | 6.7 | 0 | 3.5 |
| 3 | 10.2 | 10.2 | 10.2 | 12.8 | 0 | 2.6 |
| 4 | 15.2 | 15.2 | 15.2 | — | 0 | — |
| 5 | 17.3 | [redacted] | [redacted] | — | — | — |
| 6 | | 17.3 | 17.3 | | | |
| 7 | | | | | | |
| Average | | | | | | |

b) Find the average Time in system (1 points)

$\frac{\Sigma T}{No.of}$ $\frac{3.1 + 3.5 + 2.6}{3} = \frac{9.2}{3} = 3.067$ min

Q2) (A) Find in the meaning of the following symbols in ARENA discrete event simulation (3 points)

| Symbol | Meaning | Symbol | Meaning |
|---|---|---|---|
| Warm-up Period: | Time period specified in system when data begins no stats is taken | | Station information |

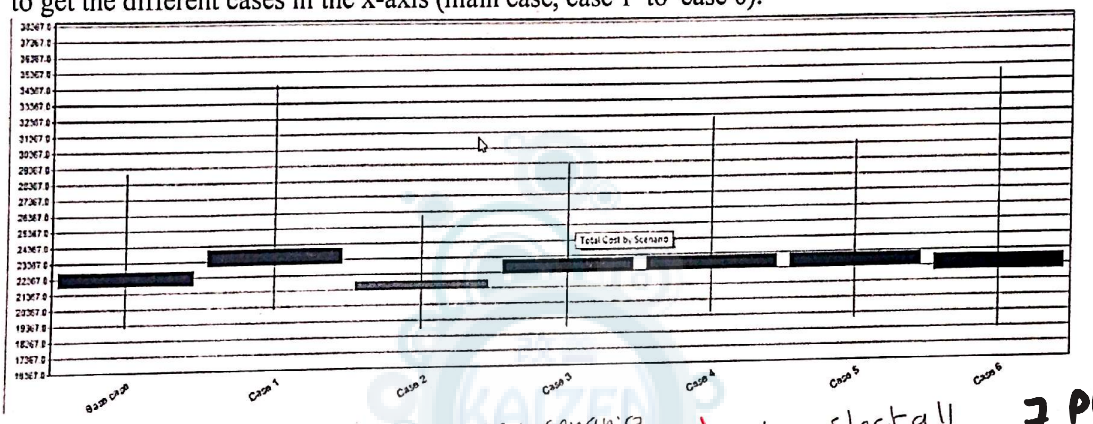
| | Time (Minutes) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Interarrival times | ~~3.2~~ | ~~7.0~~ | ~~5.0~~ | ~~2.1~~ | ~~7.3~~ | 5.8 | 17.1 | 10.8 |
| Service times | ~~3.1~~ | ~~3.5~~ | ~~2.6~~ | ~~8.5~~ | ~~0.1~~ | 1.3 | 29.0 | 3.3 |

| Arr | Dep | T | Q |
|---|---|---|---|
| 0 | 3.1 | 3.1 | 0 |
| 3.2 | 6.7 | 3.5 | 0 |
| 10.2 | 12.8 | 2.6 | 0 |
| 15.2 | 23.7 X | — | — |
| 17.3 | 23.8 X | — | — |
| 24.6 X | 25.9 X | — | — |

$$\frac{\sum T}{3} = 3.067$$

| | | | |
|---|---|---|---|
| | Fast forward run | D | Distance (animation) |
| Base Time Units: | Units used for system and output stat | Charts | Charts |
| X | variable | Warm-up Period: | period where all beginning stat are taken |

B) (3 points) Explain how to use PAN to draw the following figure Y axis is the total number of rejected calls in a call center. You change number of sales staff and number of technical support staff to get the different cases in the x-axis (main case, case 1 to case 6).




1- Process analyzer

2- new senario

4- slectall

5- run D

7 properties

8-right click

9. replicate 5 times

10- chart

11- Box and whiskers

2/3

| Scenario Properties | | control | | Responce |
|---|---|---|---|---|
| name | File | no. sales staff | no. tech staff | ~~Entity.NumberExited~~ |
| First | File.P | 1 | 1 | |
| second | File.P | 2 | 1 | |
| : | : | 3 | 2 | |
| | | 6 | 6 | |

count

stepper

Chart

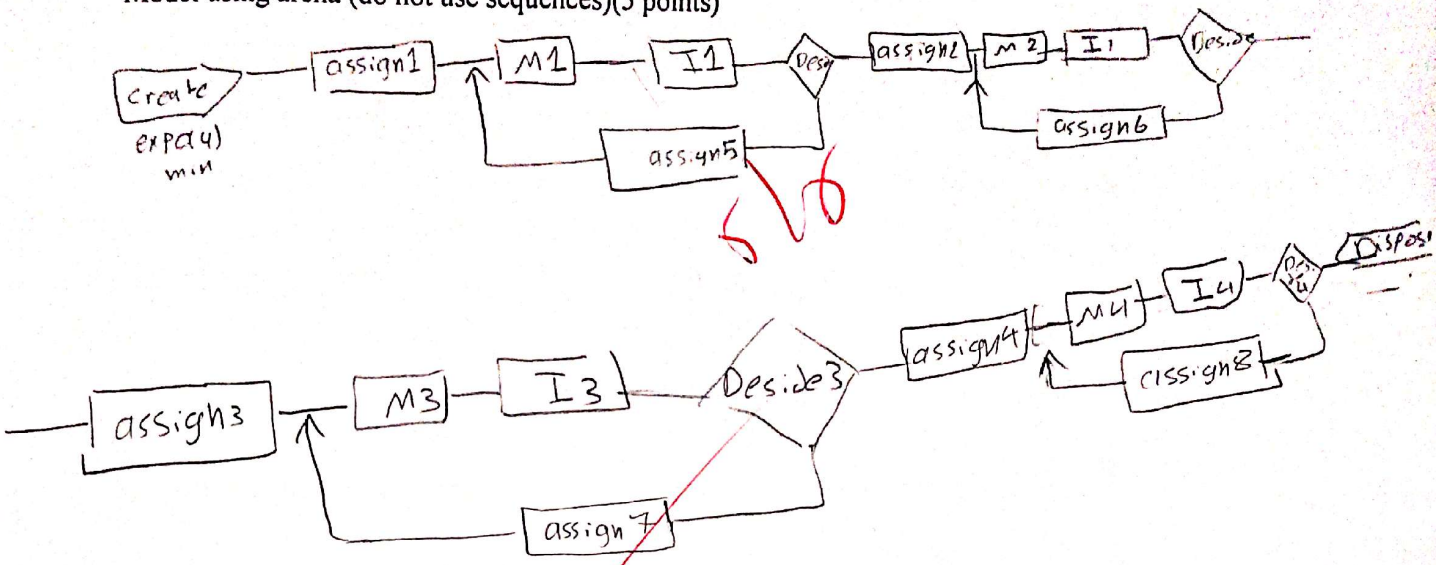
6- selectall

Q3) A high-precision machining cell consists of four workstations that every part must visit in fixed sequence: Machine 1 → Machine 2 → Machine 3 → Machine 4. Parts arrive according to an exponential distribution with mean 4 minutes. The normal (first-time) processing time on each of the four machines is TRIA(6, 10, 16) minutes, and each machine is a separate resource with capacity 1. Immediately after finishing processing on any given machine, the part is routed to an inspection station dedicated to that machine (four independent inspection stations, each taking exactly 1.5 minutes). At every inspection, regardless of which machine it follows, there is exactly a 15 % chance the part fails (independent across all inspections). If the part passes inspection, it is allowed to continue to the next machine (or exits the system after passing inspection following Machine 4). If the part fails inspection after any machine, it must immediately loop back to that same specific



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machine (not to the beginning of the line) and undergo complete rework using the same physical machine and resource; rework time on any of the four machines follows TRIA(18, 30, 45) minutes , Model using arena (do not use sequences)(5 points)




assign1
add Attribute Type 1
② Attribute M1-time
TRIA(6, 10, 16)

assign5:
Attribute M1-time
TRIA(18, 30, 45)

M1
seize Relase Delay
Resource 1
Experison minutes
M1-time

assign 2/3/4 → same as assign1

M2/M3/M4 → same as M1 with change to Resourcename

I2/I3/I4 → same as I1

I1
Size Relase Delay
Resource 5
constant
1.5 min

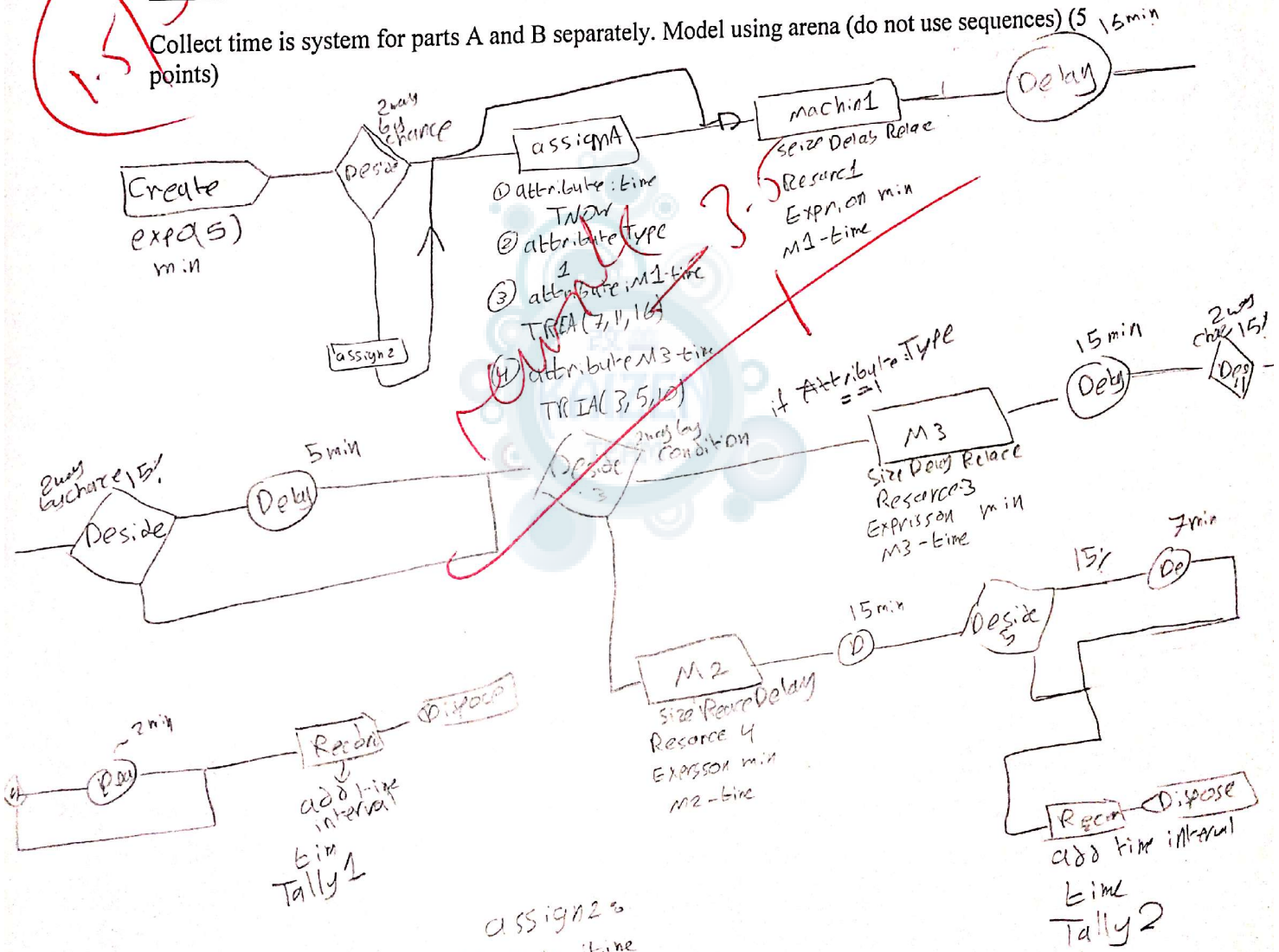
Decide 1
2way by chance
15%

all Decide are the same
assign 5, 6, 7, 8 → all same

Q4) **(Most difficult question in the exam)** A flexible manufacturing cell processes two distinct part types, Type A and Type B, that together arrive according to an exponential distribution with a mean inter-arrival time of 5 minutes, with exactly 50 % of arriving entities being Type A and 50 % being Type B. A goes to machine 1 then 3 then leaves. Part B goes to machine 1 then machine 2 then leaves. each machine is considered as a resource of capacity 1.

| Part | % | Machine 1 | Machine 2 | Machine 3 |
|---|---|---|---|---|
| A | 50 | Machine 1<br>Time: TRIA(7, 11, 16)<br>Inspection after 15 min<br>15% fail<br>Repair time: 5 min | | Machine 3<br>Time: TRIA(3, 5, 10)<br>Inspection after 15 min<br>15% fail<br>Repair time: 2 min |
| B | 50 | Machine 1<br>Time: TRIA(3, 5, 7)<br>Inspection after 15 min<br>15% fail<br>Repair time: 5 min | Machine 2<br>Time: TRIA(7, 10, 11)<br>Inspection after 15 min<br>15% fail<br>Repair time: 7 min | |

Collect time is system for parts A and B separately. Model using arena (do not use sequences) (5 points)



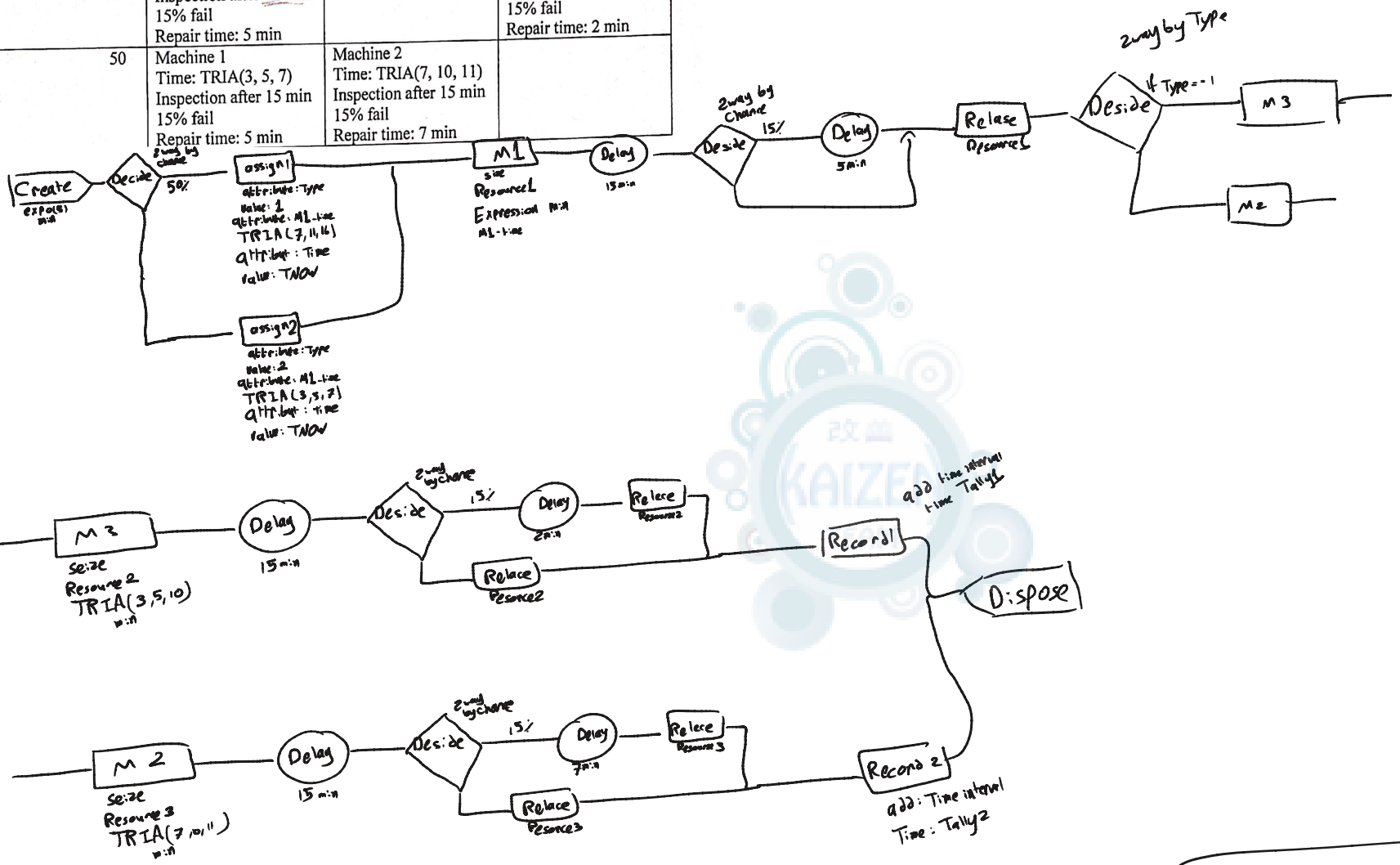

assign2
1) attribute: time
TNOW
2) attribute Type
2
3) attribute M1-time
TRIA(3, 5, 7)
4) attribute M2-time



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Q4) **(Most difficult question in the exam)** A flexible manufacturing cell processes two distinct part types, Type A and Type B, that together arrive according to an exponential distribution with a mean inter-arrival time of 5 minutes, with exactly 50 % of arriving entities being Type A and 50 % being Type B. A goes to machine 1 then 3 then leaves. Part B goes to machine 1 then machine 2 then leaves. each machine is considered as a resource of capacity 1.

| Part | % | Machine 1 | Machine 2 | Machine 3 |
|---|---|---|---|---|
| A | 50 | Machine 1<br>Time: TRIA(7, 11, 16)<br>Inspection after 15 min<br>15% fail<br>Repair time: 5 min | | Machine 3<br>Time: TRIA(3, 5, 10)<br>Inspection after 15 min<br>15% fail<br>Repair time: 2 min |
| B | 50 | Machine 1<br>Time: TRIA(3, 5, 7)<br>Inspection after 15 min<br>15% fail<br>Repair time: 5 min | Machine 2<br>Time: TRIA(7, 10, 11)<br>Inspection after 15 min<br>15% fail<br>Repair time: 7 min | |



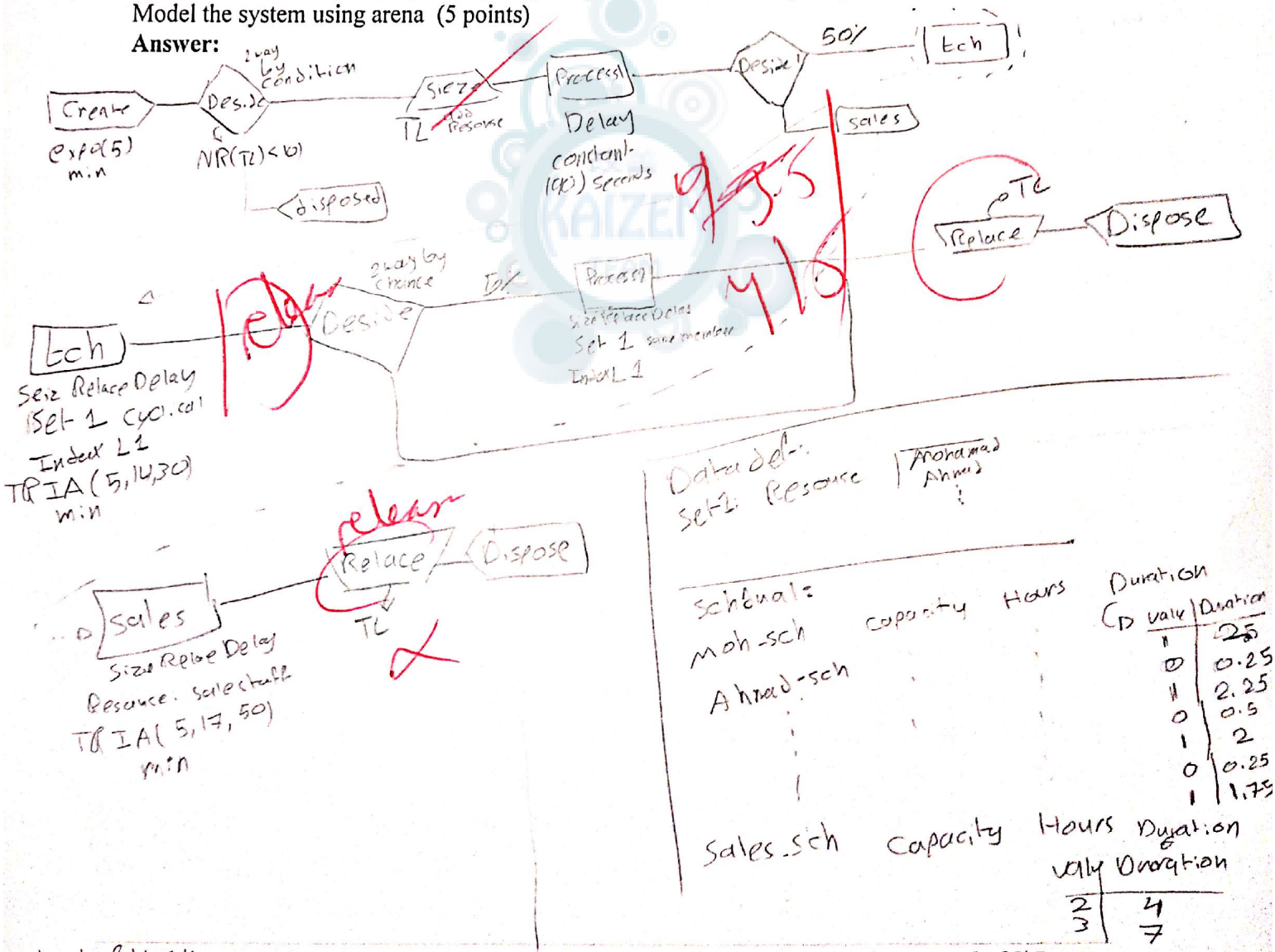

حل سؤال من جميعاتي

Q5) A 24/7 call center receives incoming calls following an exponential inter-arrival distribution with a mean of 5 minutes. The center has exactly 10 telephone lines (resource "Lines", capacity 10); any caller arriving when all 10 lines are busy receives a busy signal, is counted as a lost call, and leaves immediately (balked). Callers who seize a line first listen to a mandatory recorded welcome message lasting exactly 90 seconds, after which 50 % are routed to Technical Support and 50 % to Sales. Technical Support is handled by four staff with wok according to the following schedule. The technical support consultation time follows TRIA(5, 14, 30) minutes. After the consultation, 5 % of these calls require the same individual agent who handled the call to perform an internal archiving task that takes exactly 2 minutes (no need to call customer). The remaining 95 % end immediately.

| Agent | Shift (daily) | 30-min break | First 15-min break | Second 15-min break |
|---|---|---|---|---|
| Mohammed | 08:00–17:00 | 12:30–13:00 | 10:00–10:15 | 15:00–15:15 |
| Ahmed | 08:00–17:00 | 13:00–13:30 | 09:30–09:45 | 15:30–15:45 |
| Saeed | 08:00–17:00 | 12:00–12:30 | 10:30–10:45 | 14:30–14:45 |
| Ruaa | 08:00–17:00 | 13:30–14:00 | 09:45–10:00 | 15:15–15:30 |

Sales call takes Tria(5,17,50) min by 2 operators 8:00-12:00 and by 3 operators from 12:00-17:00. Model the system using arena (5 points)

**Answer:**




| Duration |
|---|
| 0.25 |
| 2.25 |
| 0.5 |
| 2 |
| 0.25 |
| 1.75 |

| Duration |
|---|
| 4 |
| 7 |

Data definition

Resource

TL Fixed capacity 10

Moh Based on sch

Ahmad " "

Sales Based on sch. Sales_sch

Moh-sch

Ahmad-sch

setup

Start Date and Time: 8 am



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Q6) (4 points) Write the sequence ( no mode needed) and define all needed stations for modelling

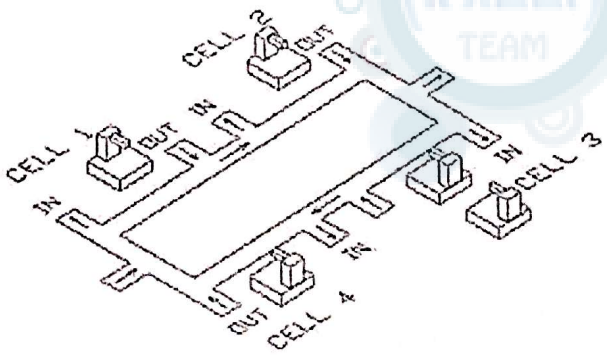



*Figure 7-1. The Small Manufacturing System Layout*



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**Table 7-1. Part Routings and Process Times**

| Part Type | Cell/Time | Cell/Time | Cell/Time | Cell/Time | Cell/Time |
|---|---|---|---|---|---|
| 1 | 1<br>6, 8, 10 | 2<br>5, 8, 10 | 3<br>15, 20, 25 | 4<br>8, 12, 16 | |
| 2 | 1<br>11, 13, 15 | 2<br>4, 6, 8 | 4<br>15, 18, 21 | 2<br>6, 9, 12 | 3<br>27, 33, 39 |
| 3 | 2<br>7, 9, 11 | 1<br>7, 10, 13 | 3<br>18, 23, 28 | | |

4/4

Data Def start at Arr

sequance

sequance 1 Arr cell 1 Att pr-time TRIA(6,8,10)

cell 2 = // (5,8,10)

cell 3 (15,20,25)

cell 4 (8,12,16)

Dep

sequance 2 cell 1 (11,13,15

// (4,6,8)

cell 2 (15,18,21)

cell 4 (6,9,12)

cell 2 // // (27,33,39)

cell 3

Dep

sequance 3 cell 2 (7,9,11)

cell 1 // // (7,10,13)

cell 3 (18,23,28)

Dep



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The University of Jordan

الجامعة الاردنية

| Form: Paper-Based Questions Cover Sheet | | |
|---|---|---|
| | Policy Number | SUI-02-01-04A |
| | Issue Number and Date | 2/3/24/2022/2963 5/12/2022 |
| | Number and Date of Revision or Modification | |
| | Deans Council Approval Decision Number | 3/ 4/24/2023 |
| | The Date of the Deans Council Approval Decision | 23/01/2023 |
| | Number of Pages | 02 |

| | | | | | |
|---|---|---|---|---|---|
| School | Engineering | | | Department | IE |
| Course Name | Simulation | | | Course No. | 0936553 |
| Academic Year | 2023/24 | Semester | 1st | Exam Type | MID |
| Exam Date | 2/12/2024 | | | Exam Time | 2:30-3:30 |

| | | | |
|---|---|---|---|
| الرقم الجامعي: 0204768 | اسم الطالب (باللغة العربية): عمر ظاهر هيمون | | |
| الرقم المتسلسل: | وقت المحاضرة: | رقم الشعبة: | اسم المدرس: زاد محمود برغش |

**Important Instructions**

1. This is a closed (open) book exam; all related material must be placed away from your desk.
2. Cell phone use is prohibited for any purpose. Your cell phone must be turned off and placed off the desk. Cell phones may not be accessed during the exam. Failure to comply may be treated as a violation of the Honor Code.
3. Headphones of any kind are not permitted.
4. This exam is (__50__) minutes long.
5. Make sure that you have ( 6 ) pages including this page.
6. This exam has ( 5 ) essay questions. Read each question carefully before answering.
7. Calculators can be used and can (*not*) be shared.
8. When you finish, you must:
9. Check that you have written your information in the spaces provided.
10. Give the exam package (all papers) to the proctor before you leave.

**For Teacher's Use Only**

| No. | ILO | SO | DL | Mark | Weight |
|---|---|---|---|---|---|
| 1 | | | 2 | 6 | 6 |
| 2 | | | 2 | 5 | 6 |
| 3 | | | 2 | 6 | 6 |
| 4 | | | 2 | 5 | 6 |
| 5 | | | 2 | 6 | 6 |

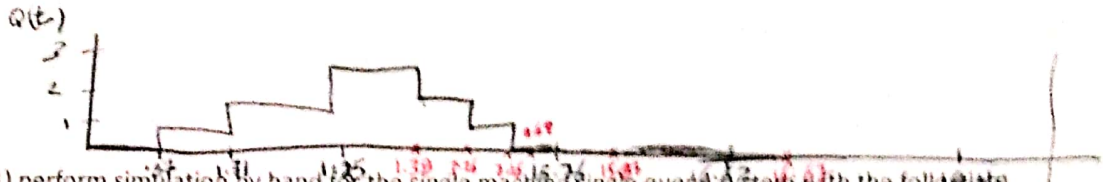
*KPI: Key Performance Indicator, ILO: Intended Learning Outcomes, SO: Student Outcomes*
*DL: Difficulty Level (1. Easy, 2. Average, 3. Hard, 4. Very Hard)*

30

**For Proctor's Remarks**



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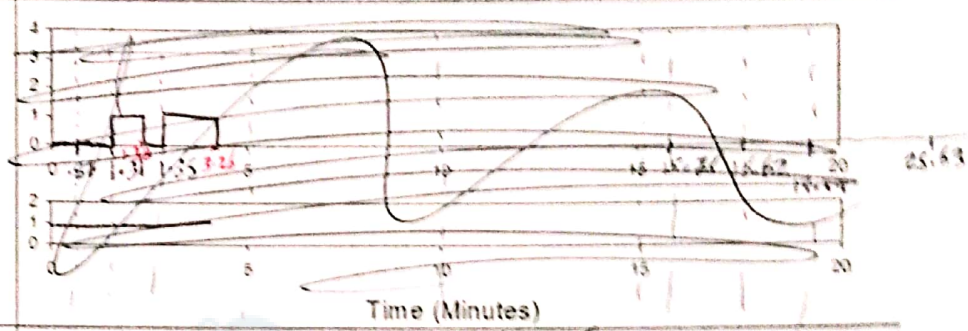



Q1) perform simulation by hand for the single machine single queue system with the following characteristics (4 points)

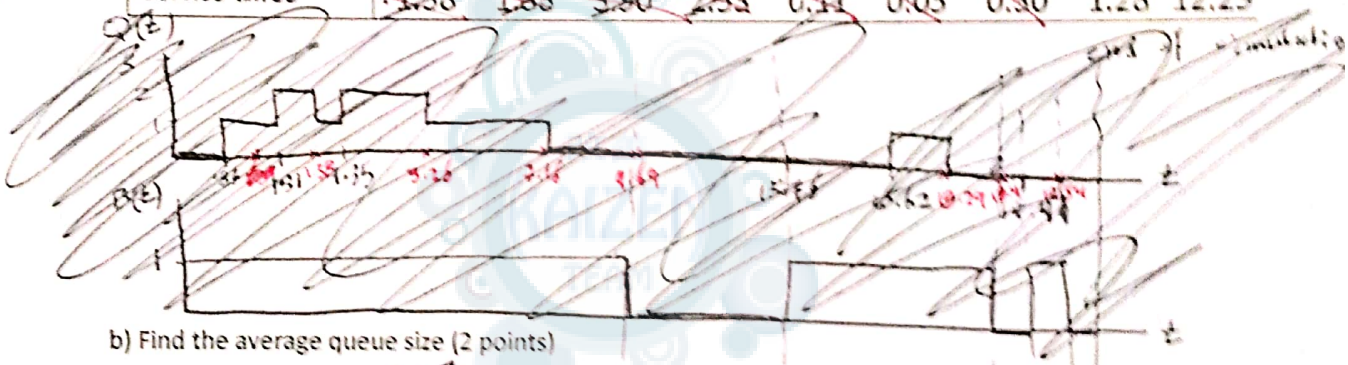
| System | Clock | B(t) | Q(t) | Arrival times of custs. in queue | Event calendar |
|---|---|---|---|---|---|
| Number of completed waiting times in queue | Total of waiting times in queue | | Area under Q(t) | | Area under B(t) |

Q(t) graph

B(t) graph



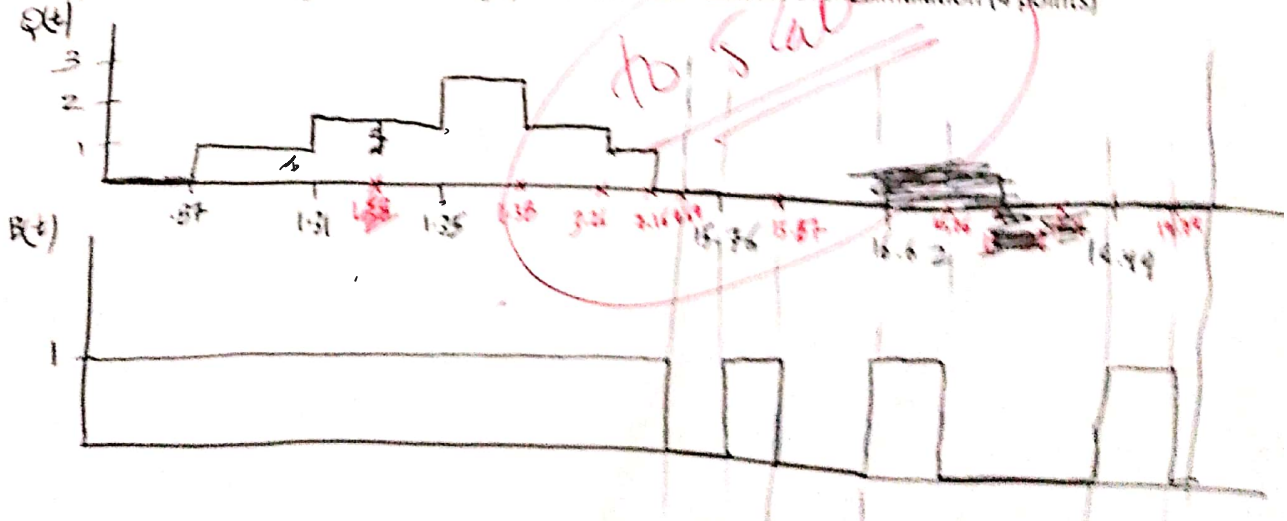

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Interarrival times | 0.87 | 0.44 | 0.04 | 14.41 | 0.86 | 2.87 | 6.14 | 4.09 | 0.31 |
| Service times | 1.38 | 1.88 | 3.90 | 2.53 | 0.11 | 0.05 | 0.30 | 1.28 | 12.29 |

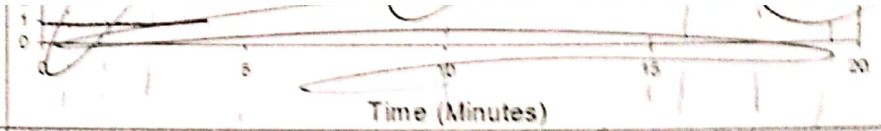



b) Find the average queue size (2 points)

$$\frac{\int_0^{20} Q(t)\,dt}{20} = \frac{8.27}{20} = 0.4135 \text{ customer}$$

Q2) Find in the meaning of the following symbols in ARENA discrete event simulation (4 points)



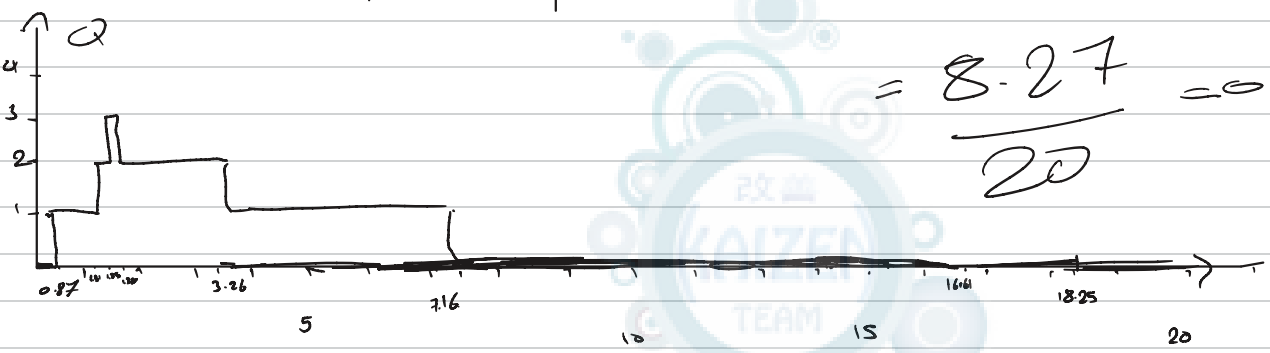
| | |
|---|---|
| B(t) graph |   |
| Interarrival times | 0.87 0.44 0.04 14.41 0.86 2.87 6.14 4.09 0.31 |
| Service times | 1.38 1.85 3.90 2.53 0.11 0.05 0.30 1.28 12.29 |

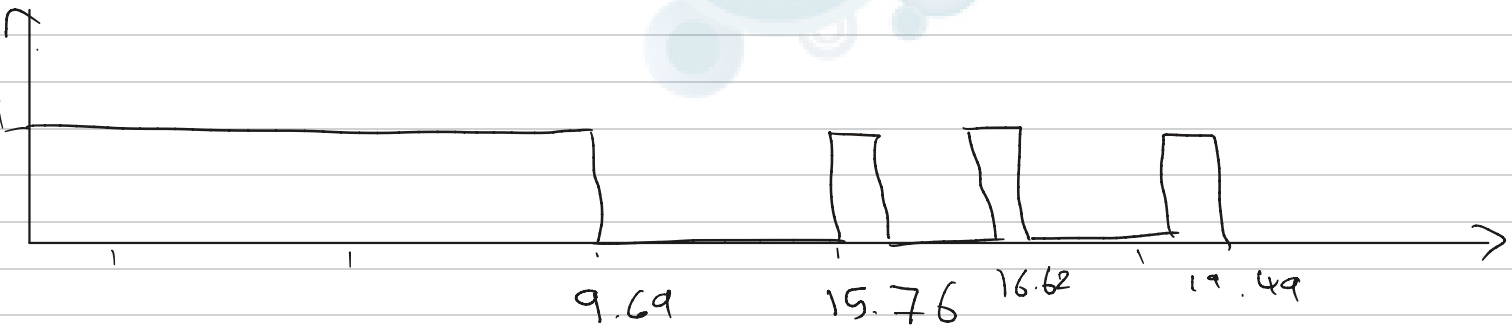
| Arr | Dep | T | Q |
|---|---|---|---|
| 0 | 1.38 | 1.38 | 0 |
| 0.87 | 3.26 | 2.39 | 0.51 |
| 1.31 | 7.16 | 5.85 | 1.95 |
| 1.35 | 9.69 | 8.34 | 5.81 |
| 15.76 | 15.87 | 0.11 | 0 |
| 16.62 | 16.67 | 0.05 | 0 |
| 19.49 | 19.79 | 0.3 | 0 |
| ~~25.62X~~ | ~~25.92X~~ | — | — |

Average Queue size:

$$\frac{0.87 + 1.31 + 1.35 + 1.38 + 3.26 + 7.16}{20}$$

$$= \frac{8.27}{20} = 0.4$$



5/6

5/4

| Symbol | meaning | Symbol | Meaning |
|---|---|---|---|
| | Segment | | Station<br>Animation |
| | fast forward | | connect two block to gether |
| Number of Replications | repeat the simulation based with different number drawn from the same distribution | Input Analyzer | analysing input distribution |
| add animation for resource. | (using random number generation) (here the no. of replications is 1) | Warm-up Period | the period where the system is not in the steady state (fluctuating) |

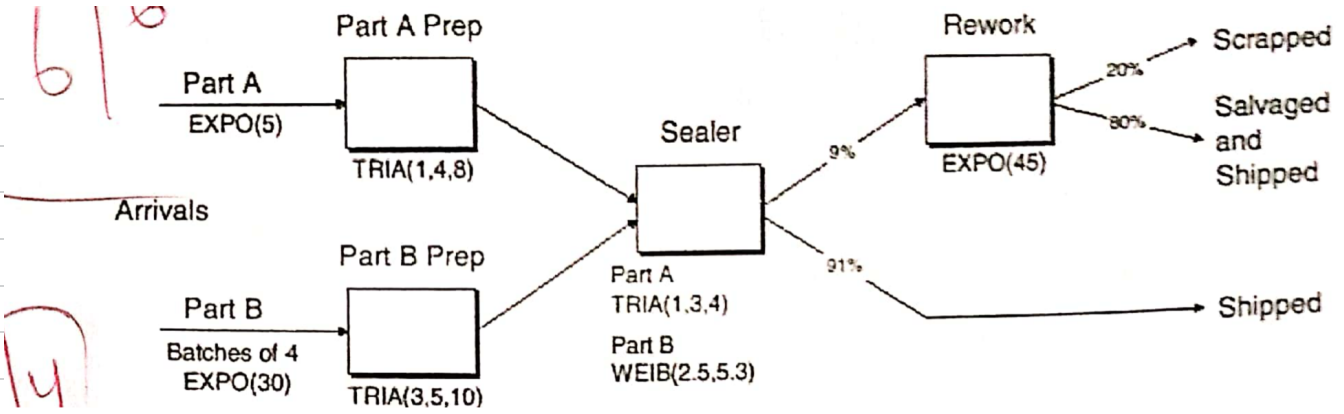
b) Describe how to add an animation for the resource, and entity (2 points)

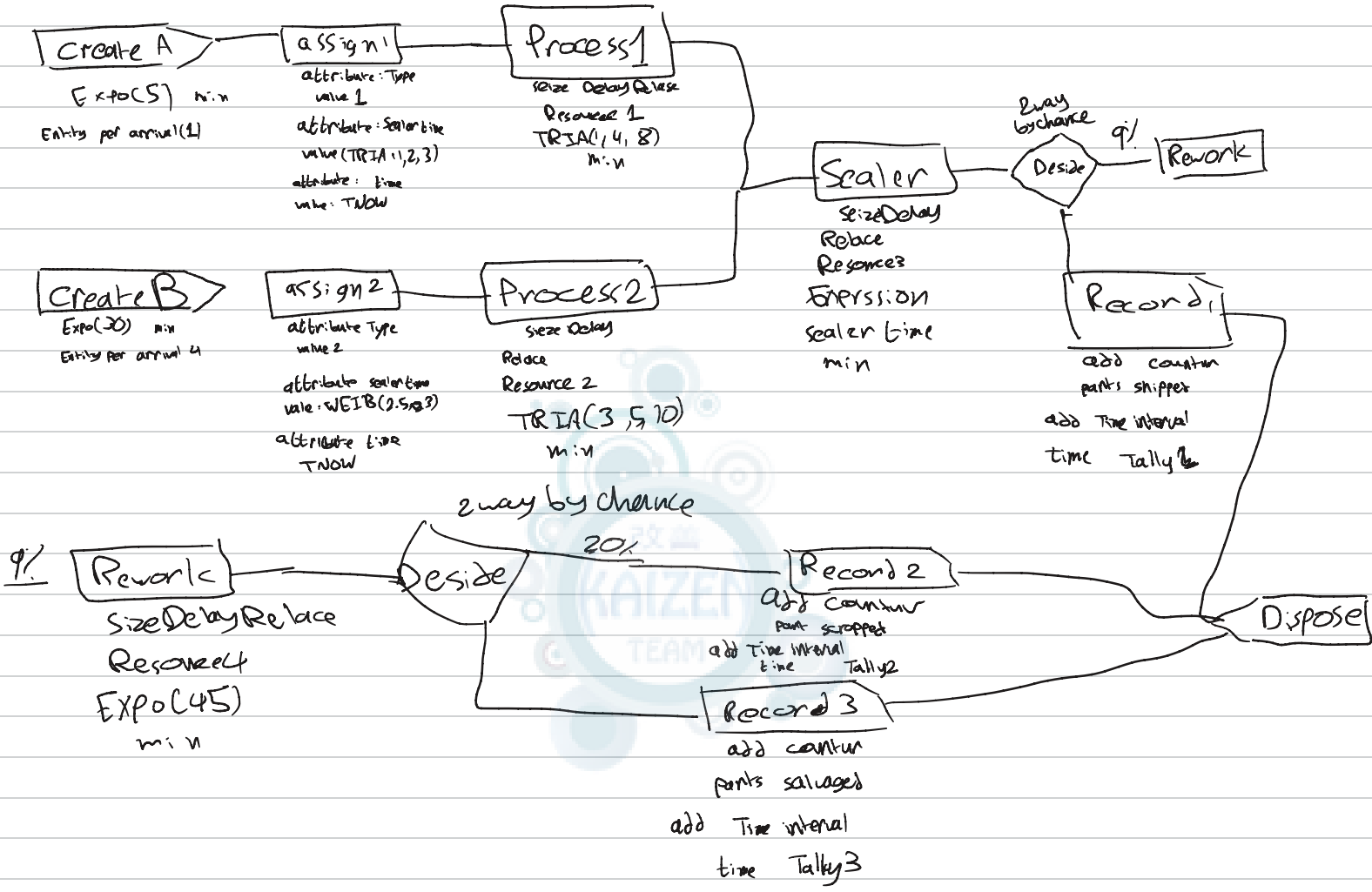
from animation > resource

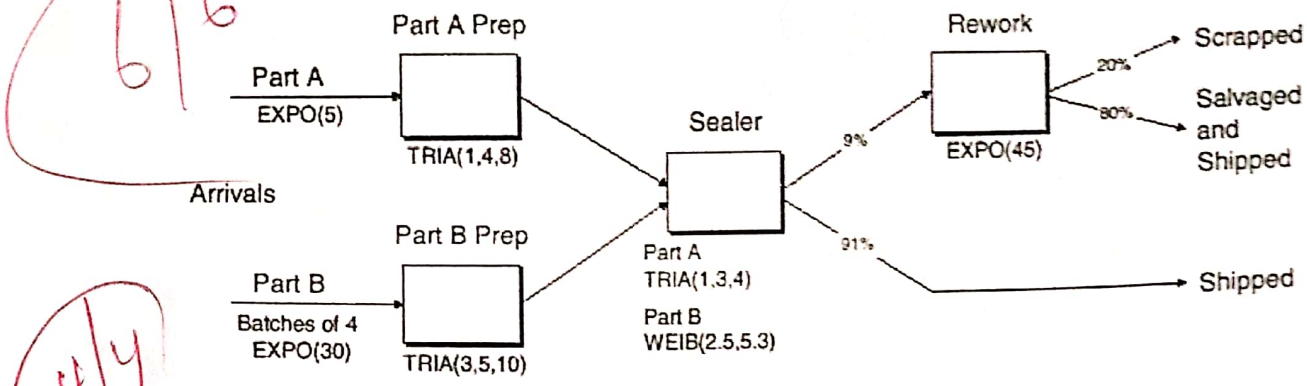
animation > entity

Q3) a) show the arena simulation for the system shown in the following figure. Add statistical collection for the number of parts produced and the time in system

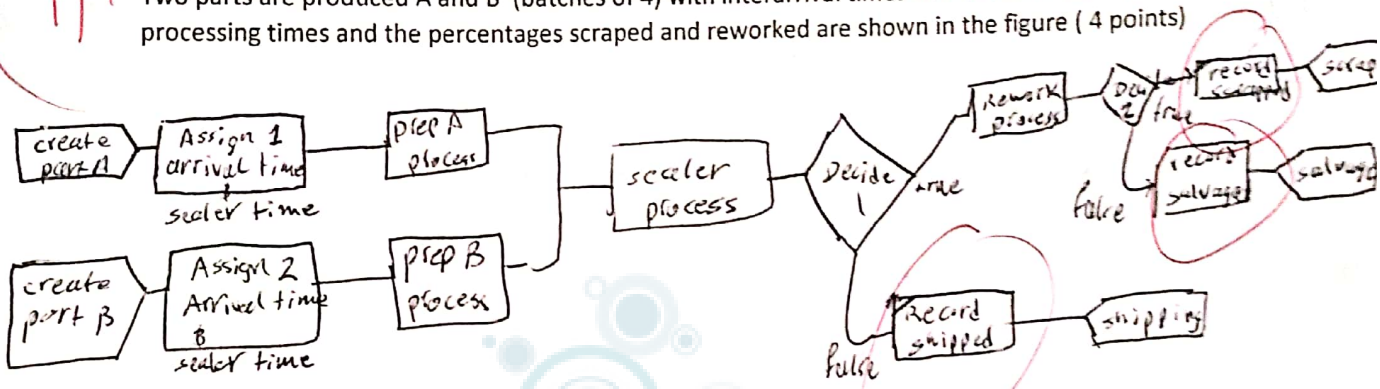
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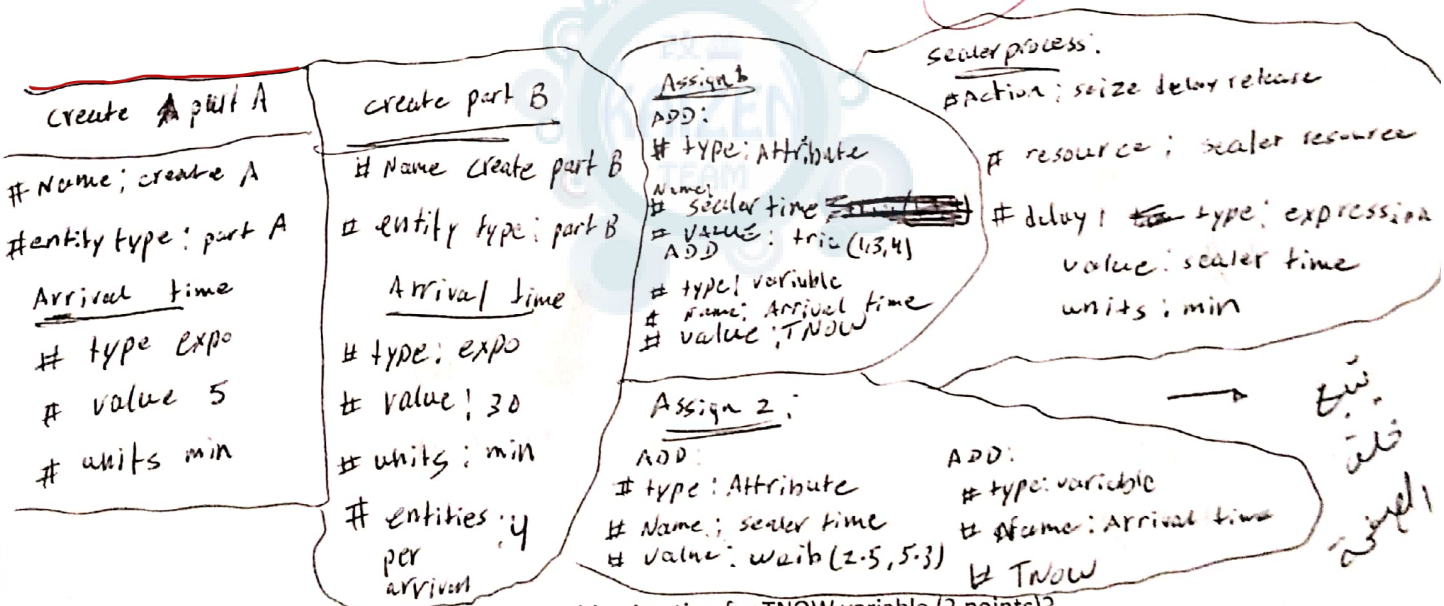

Part A Prep
Part A
EXPO(5)
TRIA(1,4,8)
Arrivals
Part B Prep
Part B
Batches of 4
EXPO(30)
TRIA(3,5,10)
Sealer
Part A
TRIA(1,3,4)
Part B
WEIB(2.5,5.3)
9%
91%
Rework
EXPO(45)
20%
80%
Scrapped
Salvaged and Shipped
Shipped


Create A
Expo(5) min
Entity per arrival(1)
assign1
attribute: Type
value 1
attribute: Sealer time
value (TRIA(1,2,3)
attribute: time
value: TNOW
Process1
seize Delay Release
Resource 1
TRIA(1,4,8)
min
Create B
Expo(30) min
Entity per arrival 4
assign2
attribute Type
value 2
attribute sealer time
value: WEIB(2.5,5.3)
attribute time
TNOW
Process2
seize Delay
Relase
Resource 2
TRIA(3,5,10)
min
Sealer
SizeDelay
Relase
Resource3
Expression
Sealer time
min
2way bychance
Deside
9%
Rework
Record1
add counter
parts shipped
add Time interval
time Tally1
2 way by chance
20%
9%
Rework
SizeDelayRelace
Resource4
EXPO(45)
min
Deside
Record 2
add counter
Part scrapped
add Time interval
time Tally2
Record 3
add counter
parts salvaged
add Time interval
time Tally3
Dispose




Two parts are produced A and B (batches of 4) with interarrival times shown in the figure, the processing times and the percentages scraped and reworked are shown in the figure ( 4 points)




b)Describe with details how to add animation for TNOW variable (2 points)?

animation > variable > variable name: TNOW > add it to flowch

2/2

prep A process:

Action: seize delay release

ADD: resource → resource name: prep A resource

delay: type → expression

value: tria(4,5,8)

unit: min

prep B process:

Action: seize delay release

ADD: resource → resource name: prep B resource

delay: type: expression

value: tria(3,5,10)

units: min

decide 1:

type: 2 way by chance

value → 80%

decide 2:

type: 2 way by chance

value → 20%

salvaged

↳ Dispose

↳ Name: salvaged.

rework process:

Action: seize delay release

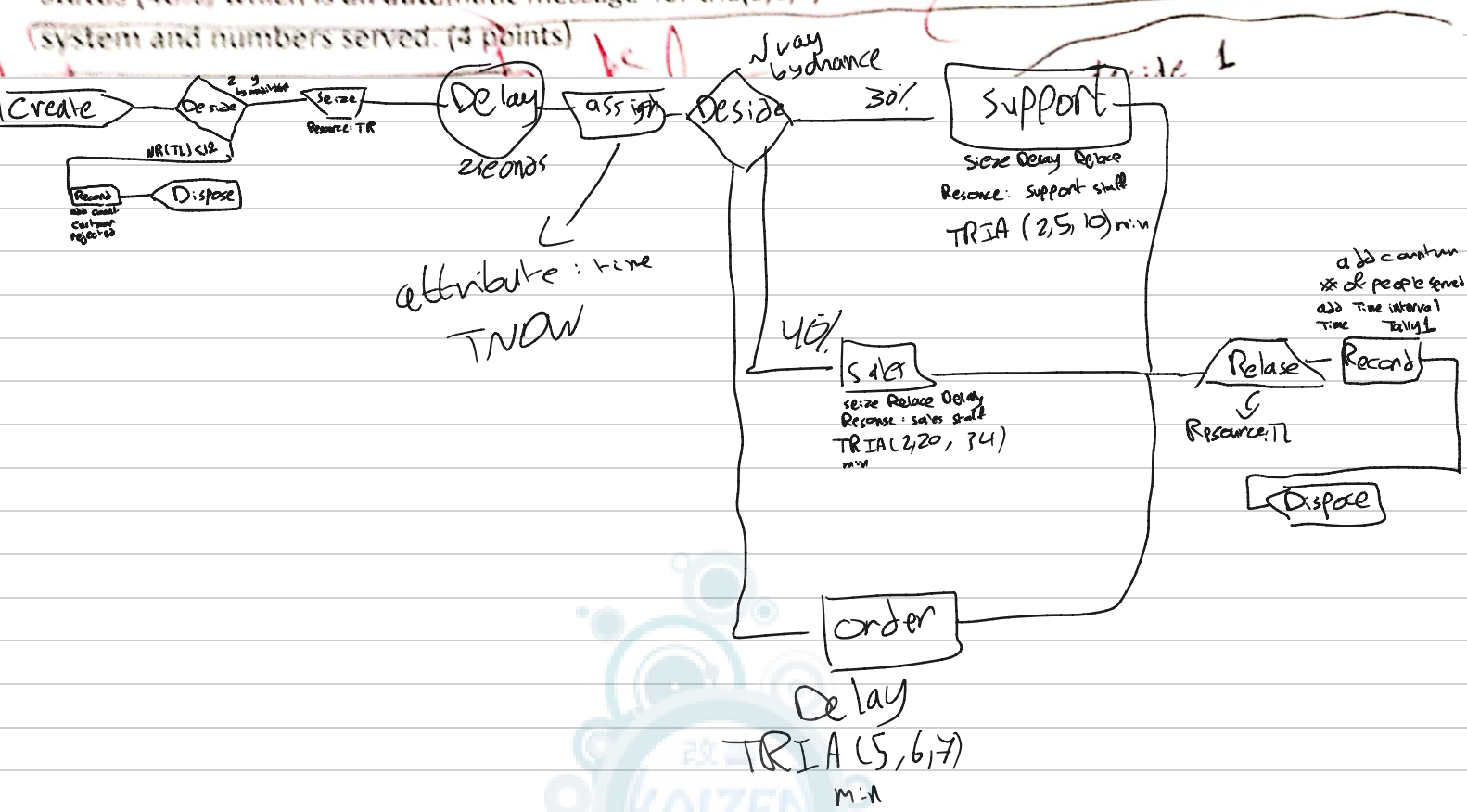
ADD: resource → resource Name: rework

delay → type: expression

value: expo(45)

units: min.

Q4) a) Show the Arena simulation for the following: a call center with 12 trunk lines if the customer finds all lines busy he will leave count the number of customers leaving this way. Customers getting in listen to automatic message for two seconds, then select one of three procedures, support (30%) two workers for 8 hr shift and 1 operator for the 8 hour evening shift it takes tria(2,5,10) minutes, sales (40%) talks with the one of fives sales staff in the morning shift only for tria(2,20, 34) minutes, and order states (40%) which is an automatic message for tria(5,6,7) minutes. Collect statistics about time in system and numbers served. (4 points)




Data Def.

schdual.

support sch Capacity Hours Duration

| value | Duration |
|---|---|
| 2 | 8 |
| 1 | 8 |

sales sch Capacity Hours Duration

| value | Duration |
|---|---|
| 5 | 8 |
| 0 | 8 |

Resources

TL Fixed Capacity 12

| | | |
|---|---|---|
| support staff | Based on schdual | support_sch |
| sales staff | Based on schdual | sales_sch |

setup: start Data and day: 8am 30 NOV 2025

manive start

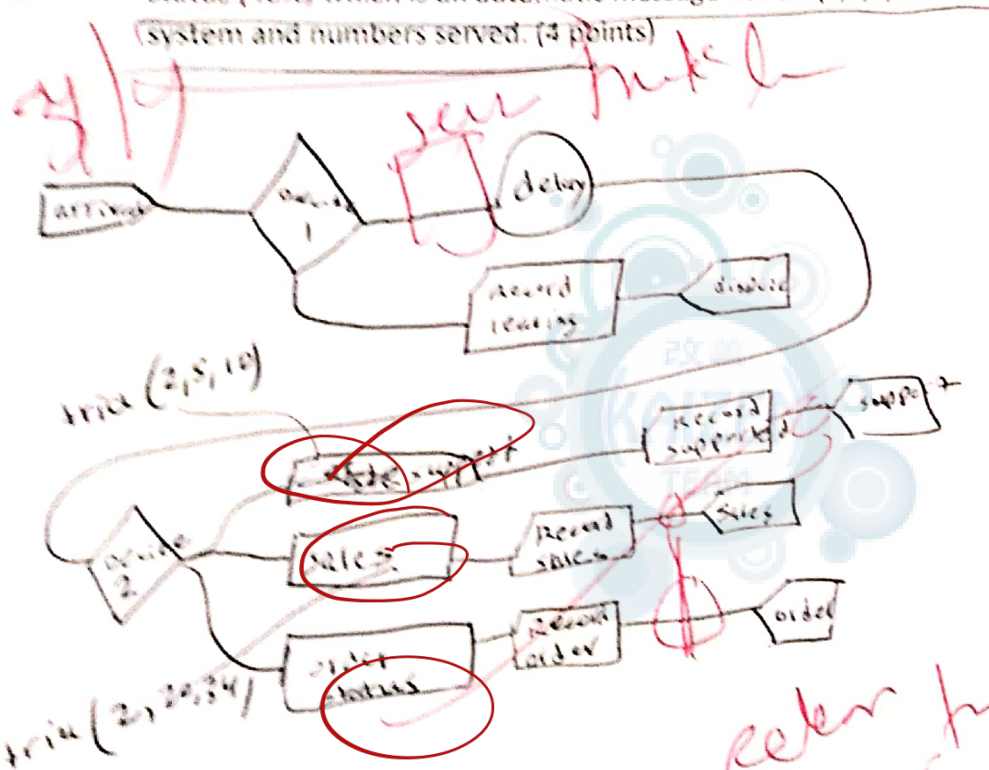
data definition → resources → trunk line → fixed capacity → Value 12
→ support → based on schedule → schedule name: support sch.
→ sales → based on schedule → schedule name: sales sch.

data definition → schedules → support sch.

| period | value |
|---|---|
| 8 | 2 |
| 9 | 1 |

→ sales sch.

Q4) a) Show the Arena simulation for the following: a call center with 12 trunk lines if the customer finds all lines busy he will leave count the number of customers leaving this way. Customers getting in listen to automatic message for two seconds, then select one of three procedures, support (30%) two workers for 8 hr shift and 1 operator for the 8 hour evening shift it takes tria(2,5,10) minutes, sales (40%) talks with the one of fives sales staff in the morning shift only for tria(2,20, 34) minutes, and order status (40%) which is an automatic message for tria(5,6,7) minutes. Collect statistics about time in system and numbers served. (4 points)



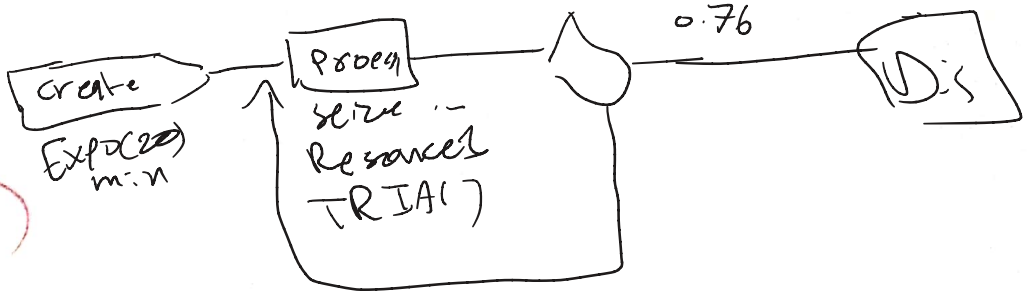

decide 1
# 2 way by condition
# NR(trunk line) < NR(trunk line

delay
type: value const
value: 2
unit sec

decide 2
30
40

b) for part a) describe how to add an animation for the number of people being served currently in the system (WIP) 2 points?

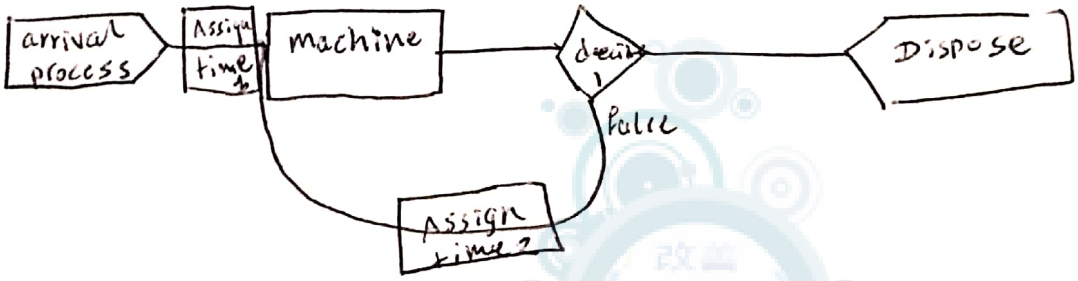
→ animation → variable → variable name NR(trunk lin

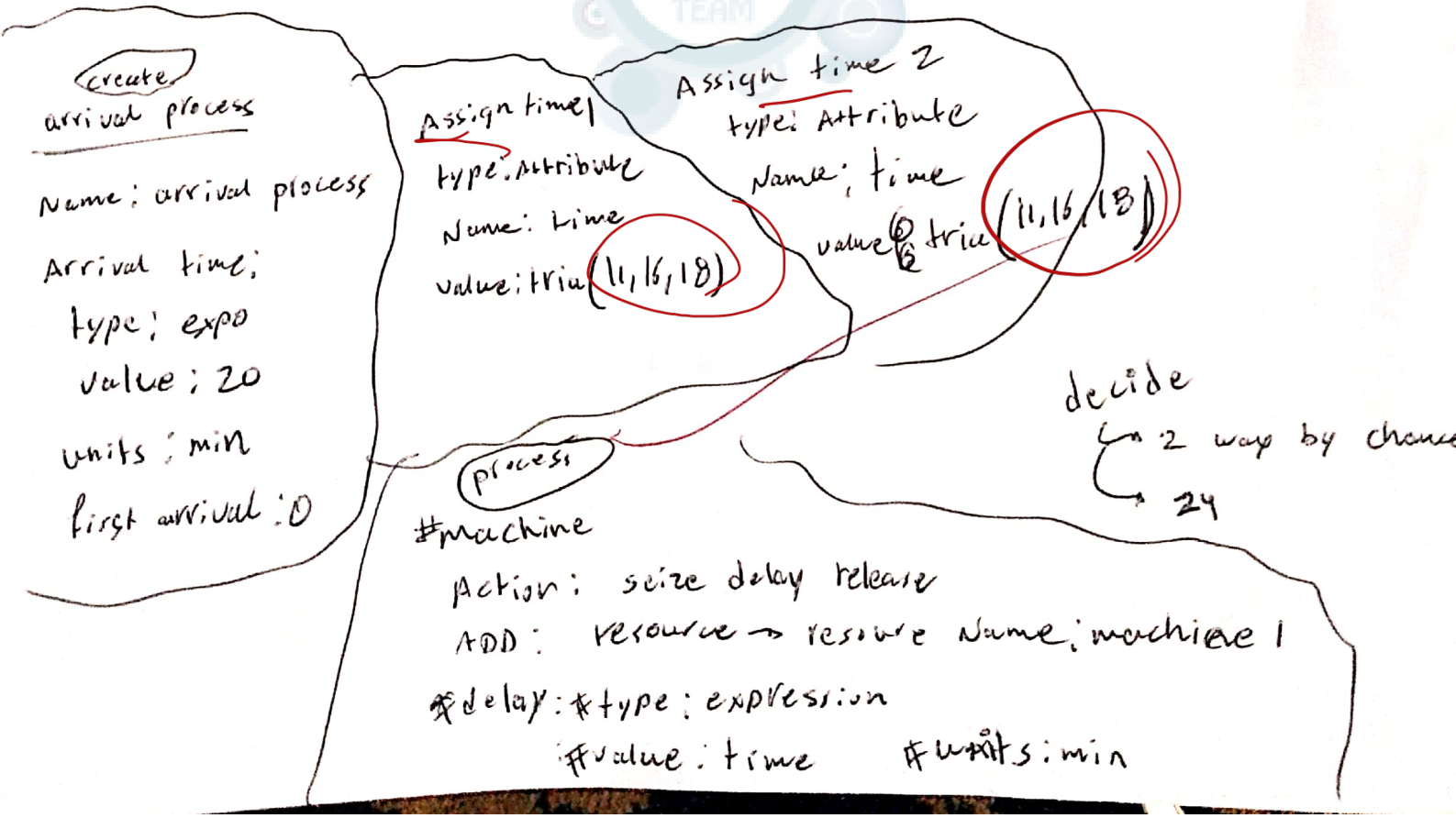



6/6

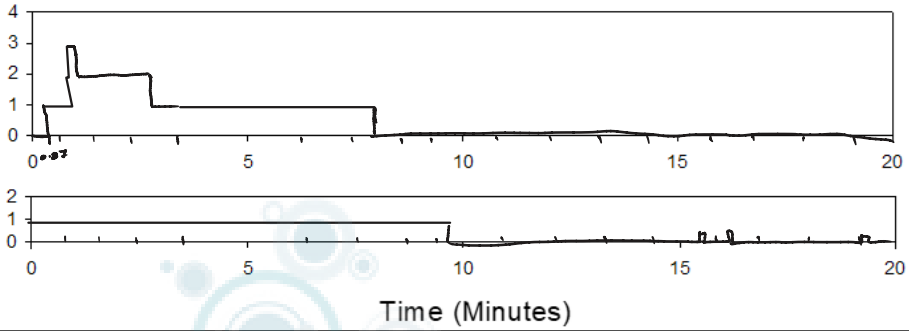
Q5) Parts arrive at a single machine system according to an exponential interarrival distribution with mean 20 minutes; the first part arrives at time 0. Upon arrival, the parts are processed at a machine. The processing-time distribution is TRIA(11, 16, 18) minutes. The parts are inspected and for each part there is a 0.24 probability that it will need

to be sent back to the same machine to be reprocessed (same processing-time distribution but a fresh draw from it, and all send-back decisions are independent of each other). There's no limit on how many times a given part might have to go through the machine for processing/reprocessing (6 points)



Q1) perform simulation by hand for the single machine single queue system with the following characteristics (4 points)

| System | Clock | $B(t)$ | $Q(t)$ | Arrival times of custs. in queue | Event calendar |
|---|---|---|---|---|---|
| Number of completed waiting times in queue | Total of waiting times in queue | | Area under $Q(t)$ | | Area under $B(t)$ |
| $Q(t)$ graph |  | | | | |
| $B(t)$ graph | | | | | |
| Interarrival times | 0.87 | 0.44 | 0.84 | 14.41 | 0.86 | 2.87 | 6.14 | 4.09 | 0.31 |
| Service times | 1.38 | 1.88 | 3.90 | 2.53 | 0.11 | 0.05 | 0.30 | 1.28 | 12.29 |

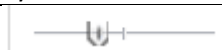
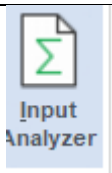


| Arr | Dep | T | Q |
|---|---|---|---|
| 0 | 1.38 | 1.38 | 0 |
| 0.87 | 3.26 | 2.39 | 0.48 |
| 1.31 | 7.16 | 5.85 | 1.95 |
| 1.35 | 9.69 | 8.34 | 5.81 |
| 15.76 | 15.87 | 0.11 | 0 |
| 16.62 | 16.67 | 0.05 | 0 |
| 19.49 | 19.79 | 0.3 | 0 |
| 25637 | | | |
| | | | |

b) Find the average queue size (2 points)

$-0.87 - 1.31 - 1.38 + 3.26 \cdots + 20$

Q2) Find in the meaning of the following symbols in ARENA discrete event simulation (4 points)

| Symbol | meaning | Symbol | Meaning |
|---|---|---|---|
|  | speed |  | station |
|  | Fast Forward |  | Connect |
|  | # of times the simulation will repeat |  | INPut Analyzer |
|  | segment |  | ليتم حسبان فيها statistics |

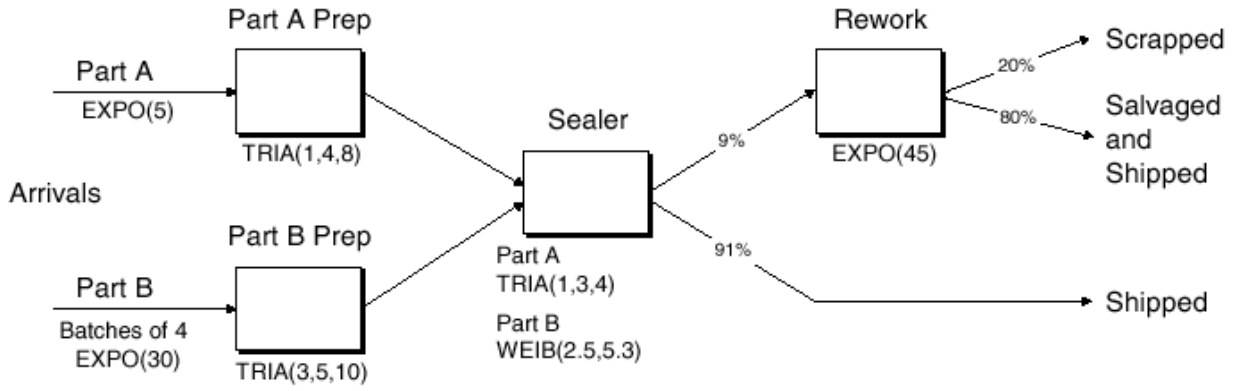
b) Describe how to add an animation for the resource , and entity (2 points)

Animate → resource → choose name of resource

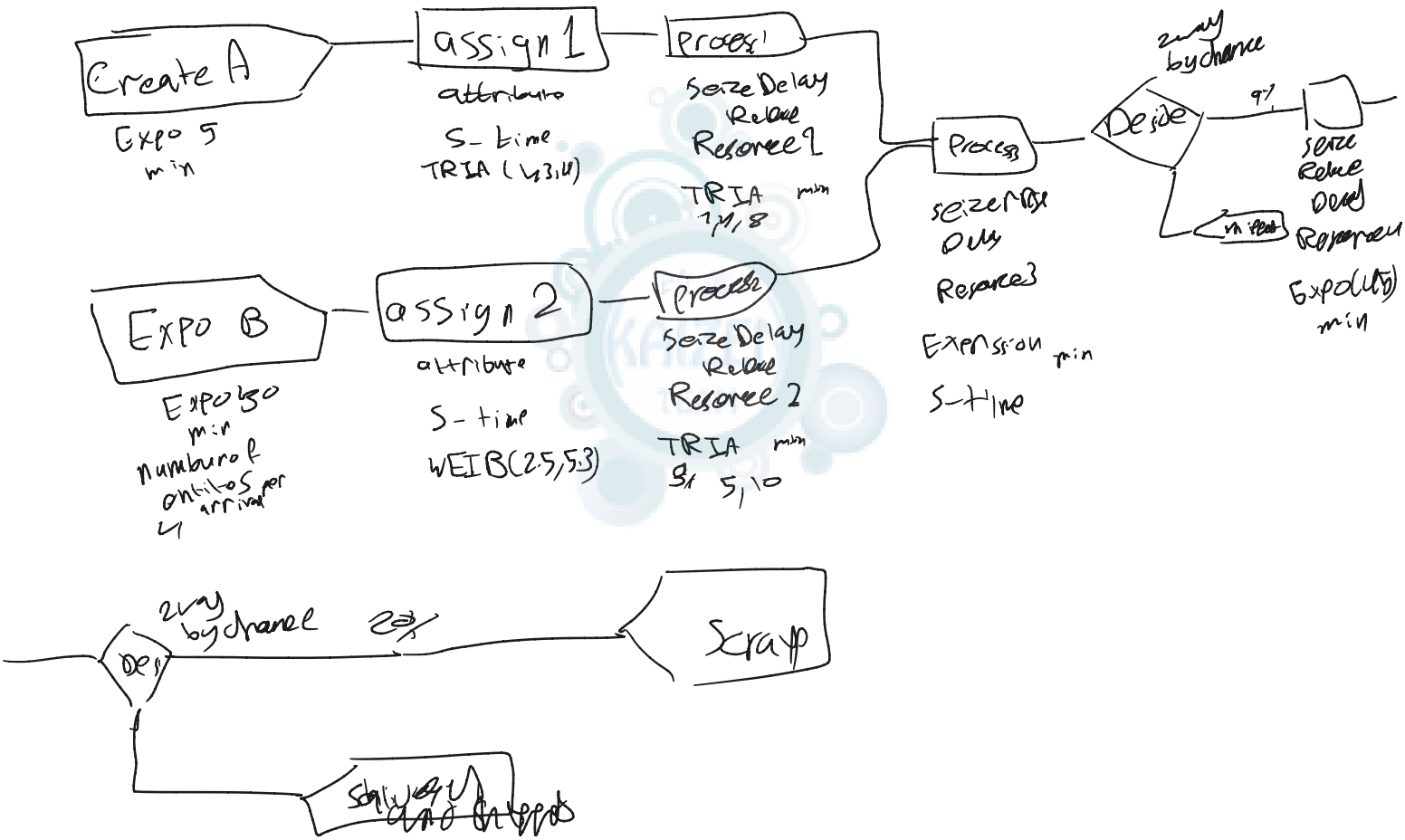
Q3) a) show the arena simulation for the system shown in the following figure. Add statistical collection for the number of parts produced and the time in system

① Animate → clock
Date
* directly

② Animate → Variable → expression TNOW




Two parts are produced A and B (batches of 4) with interarrival times shown in the figure, the processing times and the percentages scraped and reworked are shown in the figure ( 4 points)

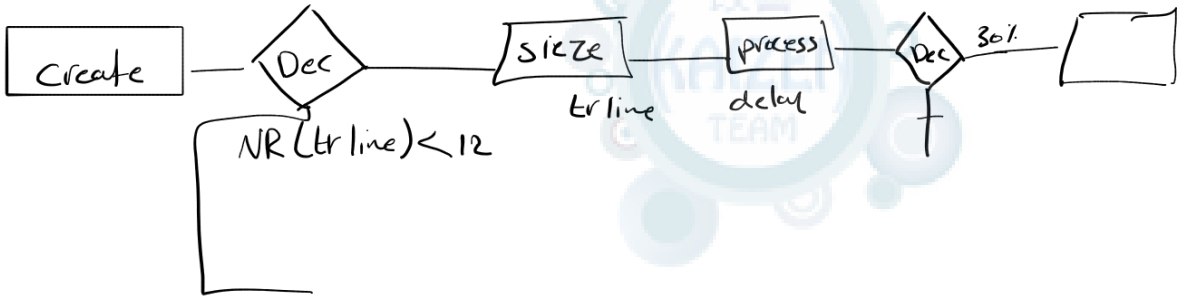



b)Describe with details how to add animation for TNOW variable (2 points)?

Animation > Variable > Variable name: TNOW > add it to flowch

Q4) a) Show the Arena simulation for the following: a call center with 12 trunk lines if the customer finds all lines busy he will leave count the number of customers leaving this way. Customers getting in listen to automatic message for two seconds, then select one of three procedures, support (30%) two workers for 8 hr shift and 1 operator for the 8 hour evening shift it takes tria(2,5,10) minutes, sales (40%) talks with the one of fives sales staff in the morning shift only for tria(2,20, 34) minutes, and order status (40%) which is an automatic message for tria(5,6,7) minutes. Collect statistics about time in system and numbers served. (4 points)

* هاني sets عشان ما يرجع يكتب مع بعض الناس مرة ثانية




b) for part a) describe how to add an animation for the number of people being served currently in the system (WIP) 2 points?

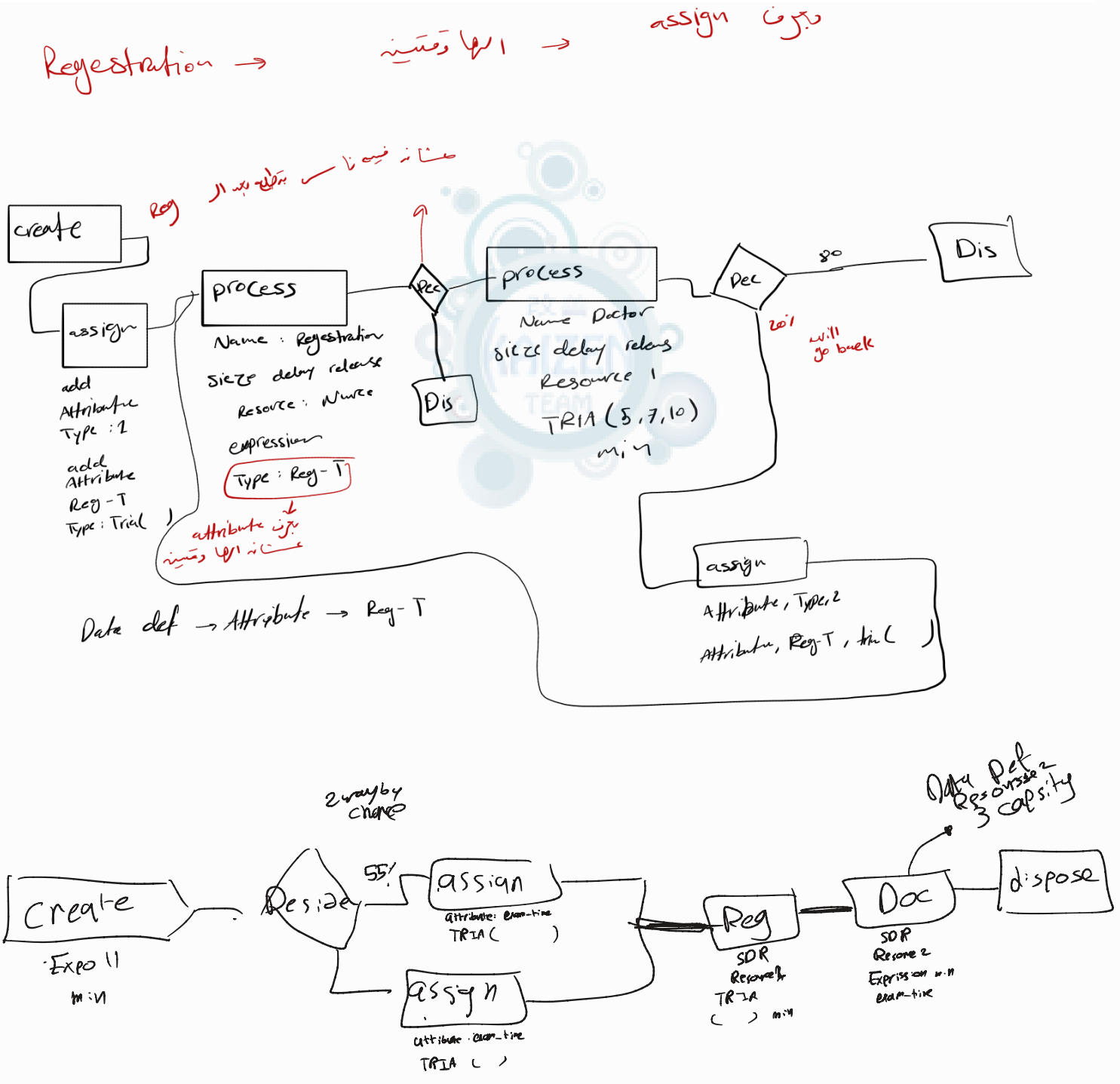
- ما فهمت
+ نضيف عداد WIP ← seize

طريقة ②
↳ entity.WIP → entity اذا نضيف

Q5) Parts arrive at a single machine system according to an exponential interarrival distribution with mean 20 minutes; the fi rst part arrives at time 0. Upon arrival, the parts are processed at a machine. The processing-time distribution is TRIA(11, 16, 18) minutes. The parts are inspected and for each part there is a 0.24 probability that it will need

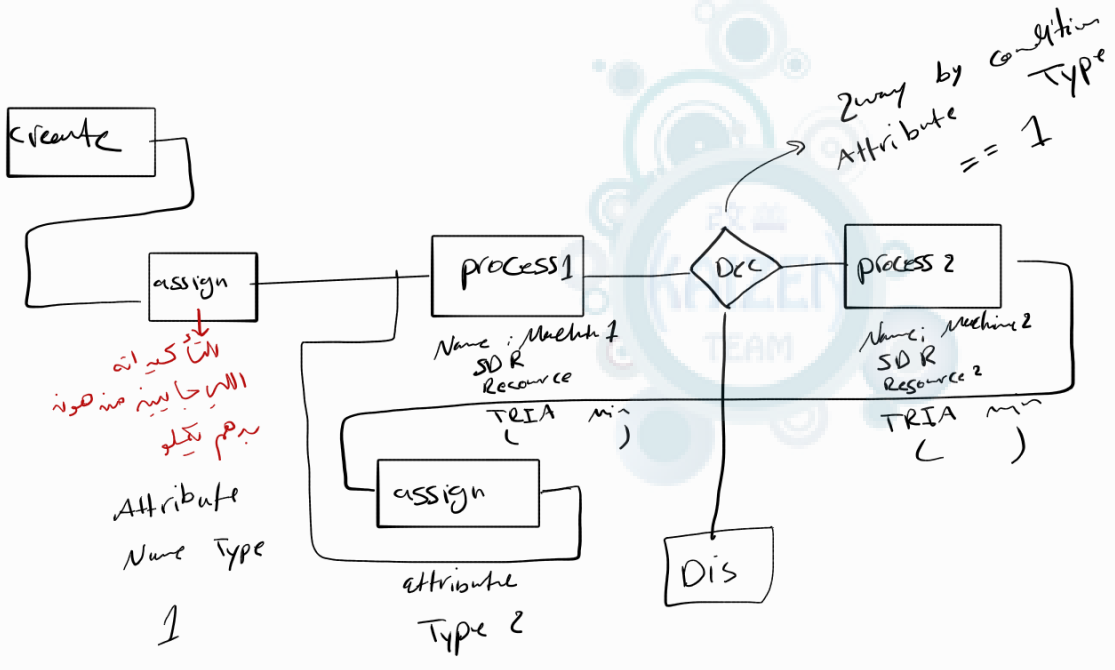
to be sent back to the same machine to be reprocessed (same processing-time distribution but a fresh draw from it, and all send-back decisions are independent of each other). There's no limit on how many times a given part might have to go through the machine for processing/reprocessing ( 6 points)

2.0 (5 points) An acute-care facility treats non-emergency patients (cuts, colds, etc.). Patients arrive according to an exponential interarrival-time distribution with a mean of 11 (all times are in minutes). Upon arrival they check in at a registration desk staffed by a single nurse. Registration times follow a triangular distribution with parameters 6, 10, and 19. After completing registration, they wait for an available examination room; there are three identical rooms. Data show that patients can be divided into two groups with regard to different examination times. The first group (55% of patients) has service times that follow a triangular distribution with parameters 14, 22, and 39. The second group (45%) has triangular service times with parameters 24, 36, and 59. Upon completion, patients are sent home. Model using arena simulation

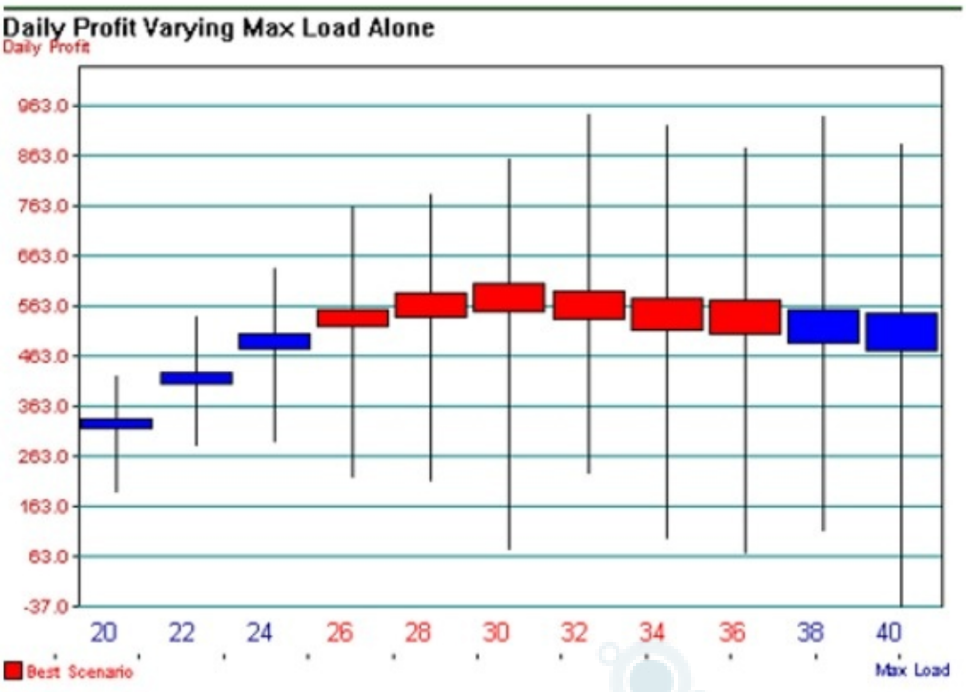


4.0 a) (5 points) Parts arrive at a two-machine system according to an exponential interarrival distribution with mean 20 minutes; the fi rst arrival is at time 0. Upon arrival, the parts are sent to Machine 1 and processed. The processing-time distribution is TRIA(4.5, 9.3, 11) minutes. The parts are then processed at Machine 2 with a processing-time distribution as TRIA(16.4, 19.1, 20.8) minutes. The parts from Machine 2 are directed back to Machine 1 to be processed a second time (same processing-time distribution as

4.0 a) (5 points) Parts arrive at a two-machine system according to an exponential interarrival distribution with mean 20 minutes; the fi rst arrival is at time 0. Upon arrival, the parts are sent to Machine 1 and processed. The processing-time distribution is



4.0 b)(4 points) describe how to use use PAN to generate the following chart from different scenarios start by defining the scenarions with variable resource capacities




* حفظ حقوان بدي اعرف ال scenarios
Controls
responses

KAIZEN TEAM

5.0 (5 points) The sequences are already defined as sequences 1 -4. Now there is a conveyor loop that goes from the arrival station to cell 1 cell2 depart then cell4 then cell3 then arrival distances is the same assume 5 units, model sing arena

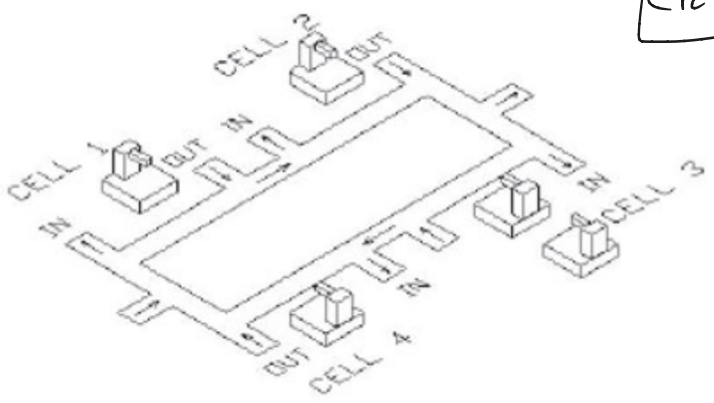



*Figure 7-1. The Small Manufacturing System Layout*

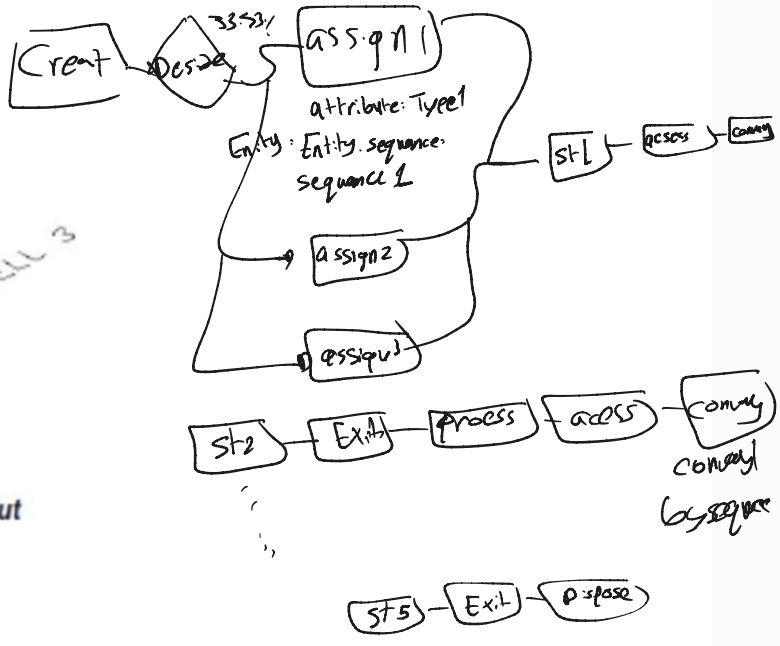



*Table 7-1. Part Routings and Process Times*

| Part Type | Cell/Time | Cell/Time | Cell/Time | Cell/Time | Cell/Time |
|---|---|---|---|---|---|
| 1 | 1<br>6, 8, 10 | 2<br>5, 8, 10 | 3<br>15, 20, 25 | 4<br>8, 12, 16 | |
| 2 | 1<br>11, 13, 15 | 2<br>4, 6, 8 | 4<br>15, 18, 21 | 2<br>6, 9, 12 | 3<br>27, 33, 39 |
| 3 | 2<br>7, 9, 11 | 1<br>7, 10, 13 | 3<br>18, 23, 28 | | |

Data Def:

segment: segment1

| begging st |
|---|
| arr |

| Next St | value |
|---|---|
| Cell1 | 5 |
| Cell2 | 5 |
| Dep | . |
| Cell3 | / |
| Cell4 | / |
| arr | / |

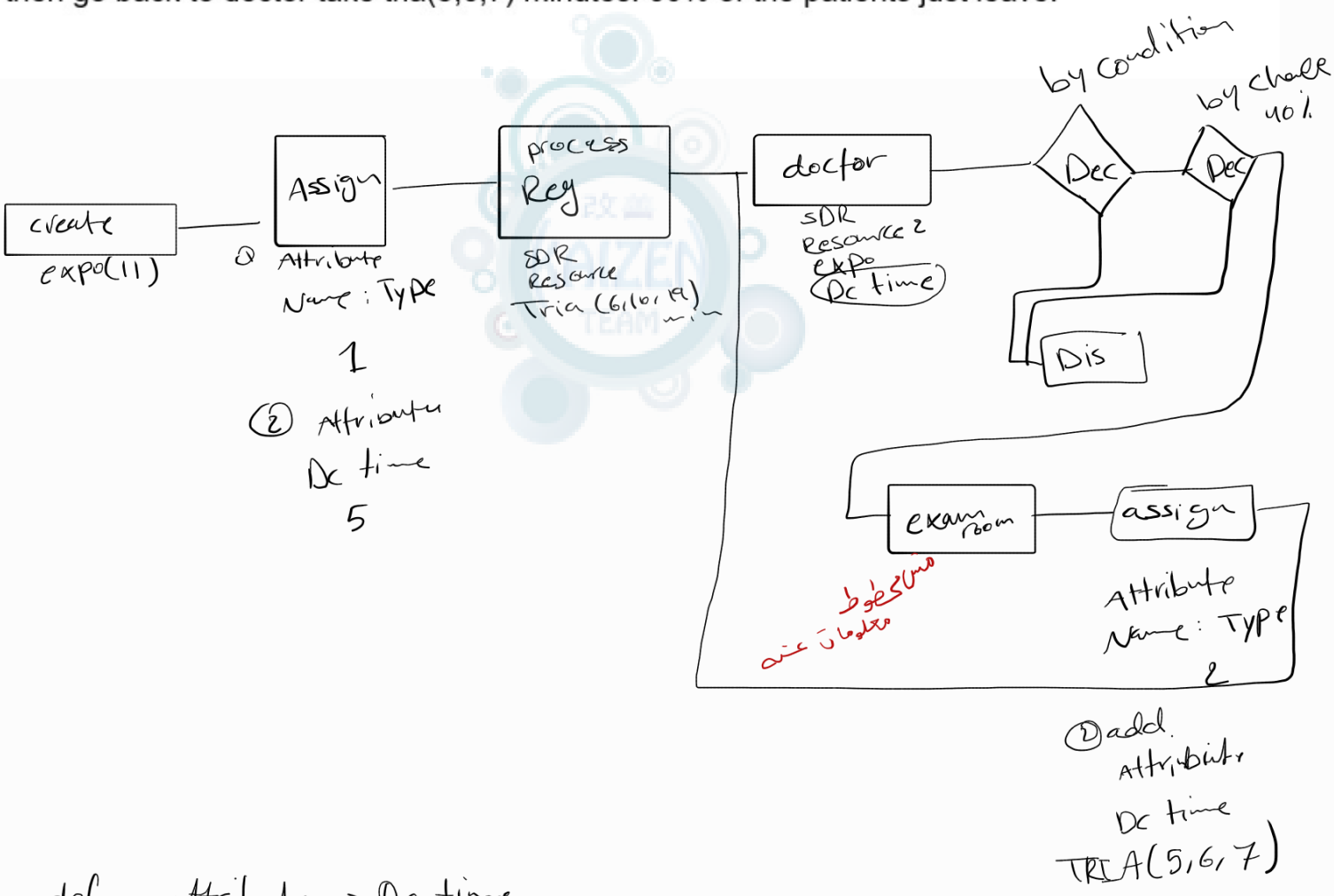
Conveyer:

Conv1 segment1

2.0 a) What are these arena symbols ( 2 points)

| | | | |
|---|---|---|---|
| In the model<br><br>- And + | | square shaped button | |

2.0 b) (5 points) An acute-care facility treats non-emergency patients (cuts, colds, etc.). Patients arrive according to an exponential interarrival-time distribution with a mean of 11 (all times are in minutes). Upon arrival they check in at a registration desk staffed by a single nurse. Registration times follow a triangularn distribution with parameters 6, 10, and 19. The patient goes to the doctors for 5 mins then 40% of patients go to exam room then go back to doctor take tria(5,6,7) minutes. 60% of the patients just leave.




Data def → attribute → Dc time

DeC 1 → exam room انه اللي راجع من ال
على الاكيد رح يغادر

2way by condition
Type == 1

3.0 (5 points) model the call center with the following specs:

One phone number for customers to call in to 26 trunk lines, one needed for each call (incoming or outgoing, talking or on hold) Arriving call finding no free trunk lines gets busy signal, goes away Count number of such rejected calls Calls arrive with interarrivals ~ EXPO (0.857) min.

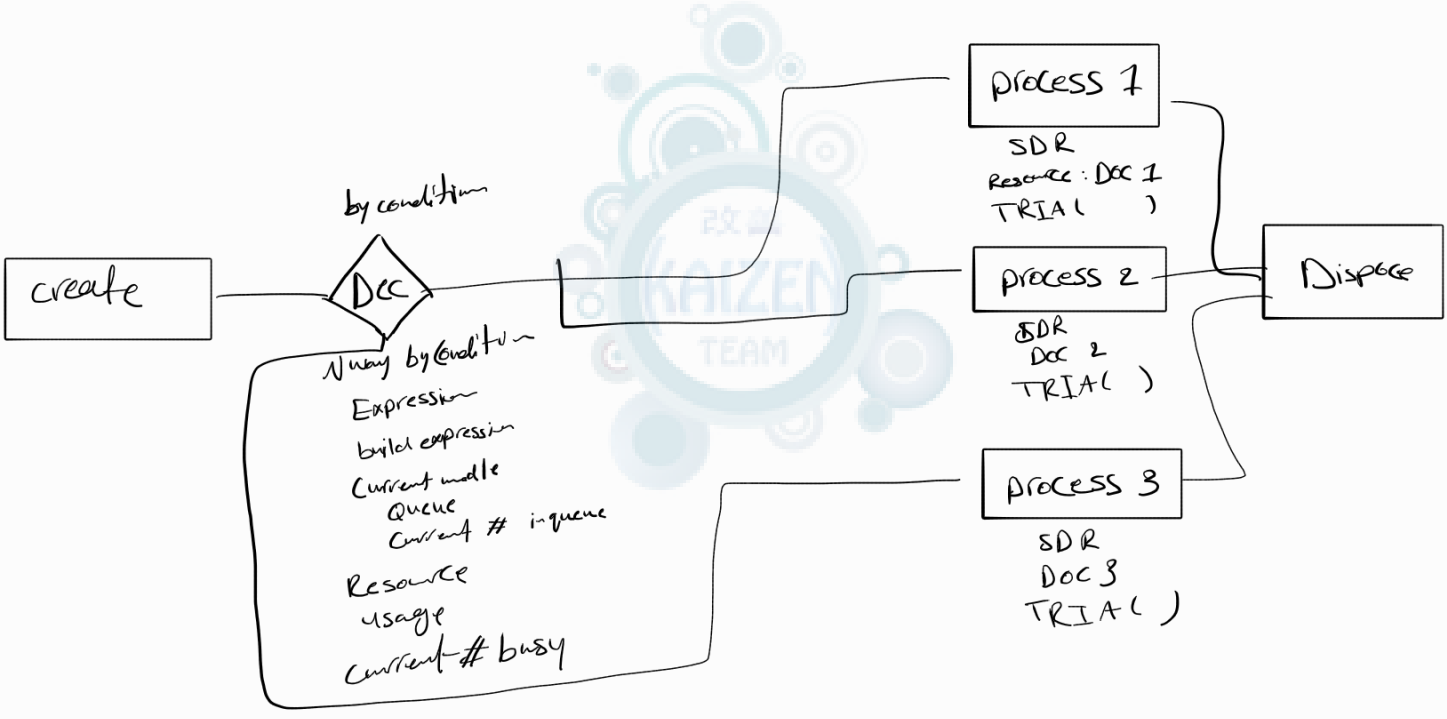
First call arrives at time 0 Three incoming call types Initial recording to decide ~ UNIF (0.1, 0.6) min.

Tech support (76%), sales (16%), order status (8%) Tech-support calls For product type 1 (25%), 2 (34%), or 3 (41%) Needs qualified tech-support person Two for type 1, three for type 2, three for type Separate FIFO queues for each type Conversation time ~ TRIA (3, 6, 18) min. for all types Then leaves system

Sales calls All the same Four sales staff, all the same One FIFO queue feeding all sales staff Conversation time ~ TRIA (4, 15, 45) Then leaves system

4.0 a)(5 points) Trucks arrive with EXPO(9.1) interarrival times (all times are in minutes) to an unload area that has three docks; the fi rst truck arrives at time 0. The unload times are TRIA(25, 28, 30), TRIA(23, 26, 28), and TRIA(22, 25, 27) for docks 1, 2, and 3, respectively. If there is an empty dock, the truck proceeds immediately to that dock. Assume zero travel times to all docks. If there is more than one empty dock, the truck places preference on the higher-numbered dock (3, 2, 1). If all the docks are busy, it chooses the dock with the minimum number of trucks waiting. If there is a tie, it places preference on the lowest numbered dock (1, 2, 3). Note that in "by Condition" Decide modules, the tests are done from top to bottom, and the fi rst one resulting in a "true" sends the entity out through that corresponding exit point. Model using arena

2 conditions




NQ (process 1 . Queue) + NR(Doc 1) <= NQ (process 2 . Queue) + NR(Doc 2) and

NQ (process 1 . Queue) + NR(Doc 1) <= NQ (process 3 . Queue) + NR(Doc 3)

another add

NQ (process 2 . Queue) + NR(Doc 2) <= NQ (process 3 . Queue) + NR(Doc 3)

NQ + NR → العدد الكلي لـ process

NQ ← العدد في Q

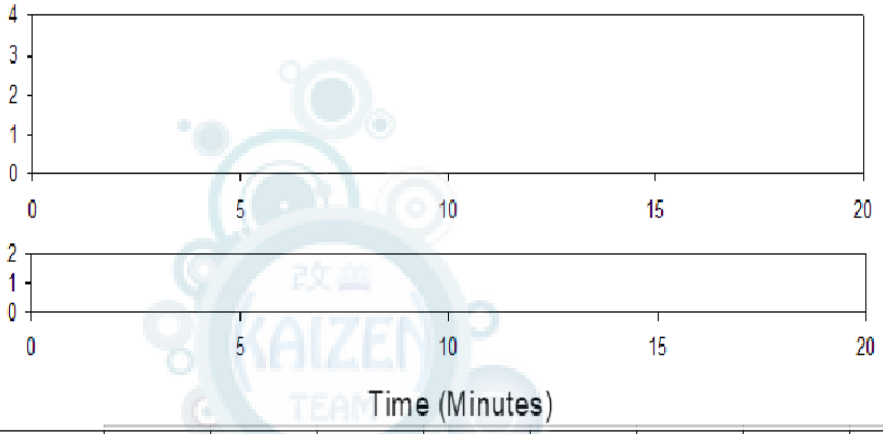
NR ← busy Resources

1.0 a) Solve the following using hand simulation (4 points)

| System | Clock | $B(t)$ | $Q(t)$ | Arrival times of custs. in queue | Event calendar |
|---|---|---|---|---|---|
| Number of completed waiting times in queue | Total of waiting times in queue | | Area under $Q(t)$ | | Area under $B(t)$ |

$Q(t)$ graph

$B(t)$ graph




| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Interarrival times | 3.67 | 4.58 | 1.61 | 2.26 | 1.34 | 3.51 | 8.79 | 1.49 | 2.24 |
| Service times | 5.66 | 5.06 | 0.53 | 2.59 | 0.18 | 2.87 | 7.15 | 0.47 | 0.47 |

1.0 b)Using linear congruential technique generate next three random numbers ([0-1]) parameters a=13 , c=33 m=117 X0=17 (3 points)

$X_1 = aX_0 + c \mod M$

$= 13 \times 17 + 33 \mod 117$

$= 254 \mod 117$

$X_1 = 20 \quad R_1 = \frac{20}{117} = 0.171$

$X_2 = 13 \times 20 + 33 \mod 117$

$293 \mod 117$

$= 59$

$X_2 = 59 \quad R_2 = 0.504$

$X_3 = 13 \times 59 + 33 \mod 117$

$X_3 = 98 \quad R_3 = 0.838$

1.0 c) For the rand numbers [0,0.1] {0.207, 0.412 0.115] generate exponential distribution random numbers with mean (1/λ) = 5 (3 points)

$\frac{-1}{\lambda} \ln(1-R)$

1 $-5 \ln(1-0.207)$

$= 1.15966$

2 $-5 \ln(1-0.412)$

$= 2.655$

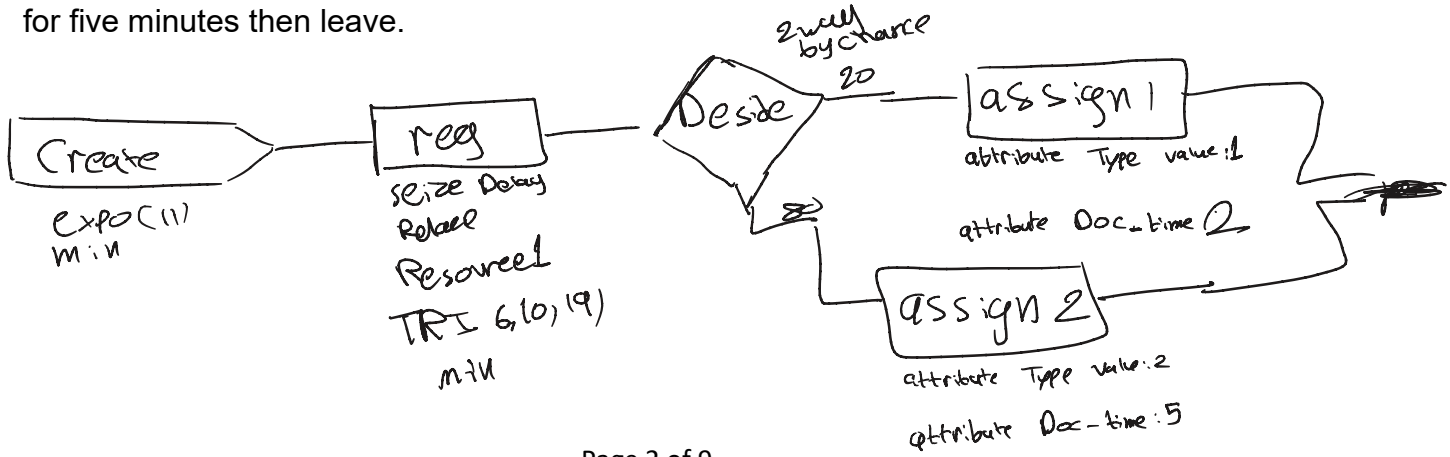
3 $-5 \ln(1-0.115)$

$= 0.611$

2.0 a) What are these arena symbols ( 2 points)

| | | | |
|---|---|---|---|
| Hold | Hold entity in a queue until specific condition is meet or a signal is recived | Warm-up Period: 0.0 | make system reach a steady state |

2.0 b)(5 points) An acute-care facility treats non-emergency patients (cuts, colds, etc.). Patients arrive according to an exponential interarrival-time distribution with a mean of 11 (all times are in minutes). Upon arrival they check in at a registration desk staffed by a single nurse. Registration times follow a triangular distribution with parameters 6, 10, and 19. Patients wait for the doctor, two type of patients type 1 (20%) sees the doctor for 2 mins then go to exam room for 5 mins then leaves. Type 2 (80 %) patients see the doctor for five minutes then leave.

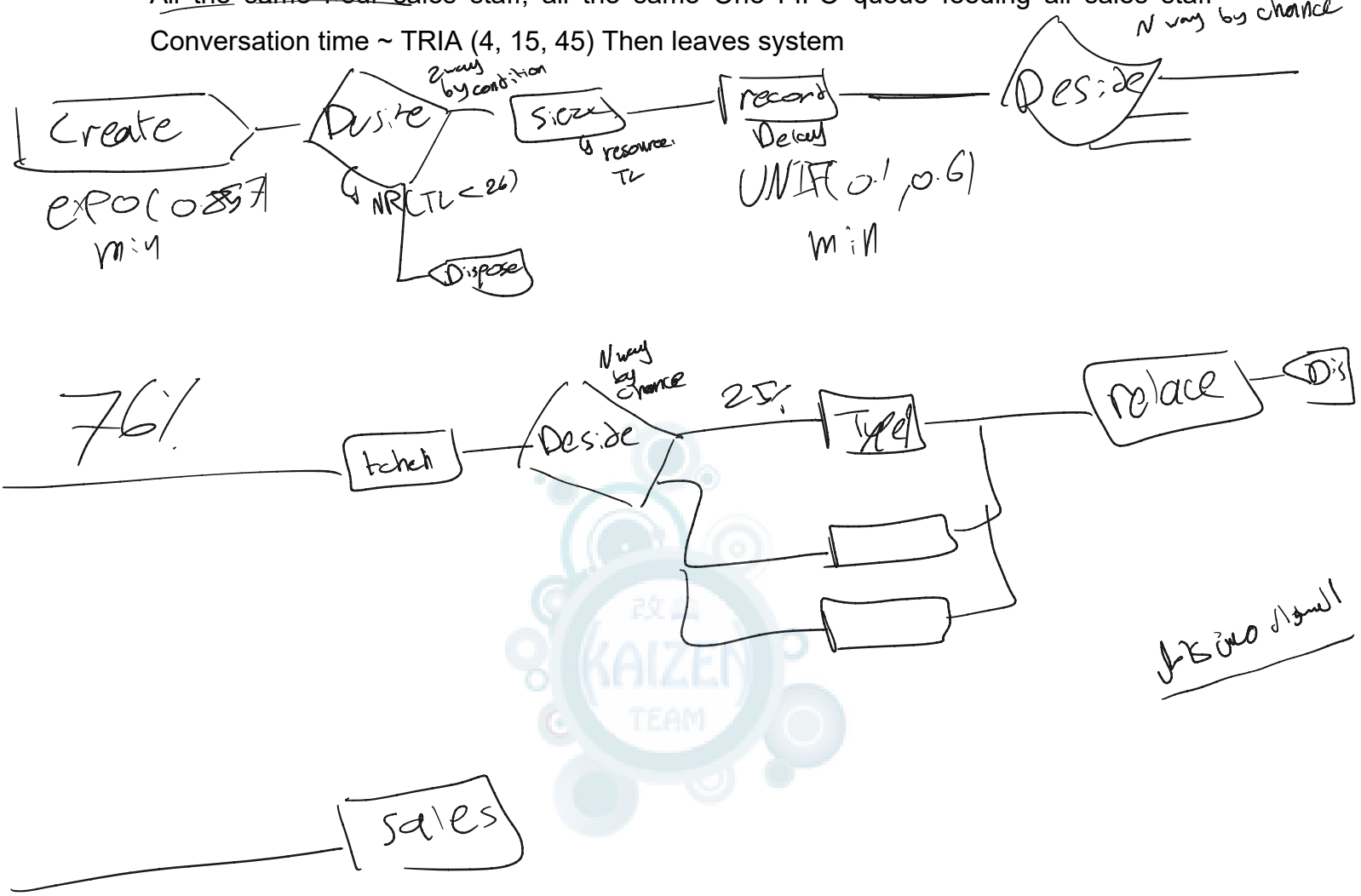





3.0 (5 points) model the call center with the following specs:

One phone number for customers to call in to 26 trunk lines, one needed for each call (incoming or outgoing, talking or on hold) Arriving call finding no free trunk lines gets busy signal, goes away Count number of such rejected calls Calls arrive with interarrivals ~ EXPO (0.857) min. First call arrives at time 0 Three incoming call types Initial recording to decide ~ UNIF (0.1, 0.6) min. Tech support (76%), sales (16%), order status (8%) Tech-support calls For product type 1 (25%), 2 (34%), or 3 (41%) Needs qualified tech-support person Two for type 1, three for type 2, three for type Separate FIFO queues for each type Conversation time ~ TRIA (3, 6, 18) min. for all types Then leaves system Sales calls

All the same Four sales staff, all the same One FIFO queue feeding all sales staff
Conversation time ~ TRIA (4, 15, 45) Then leaves system




Data Definition

Resource TL capasty 26 → for Tech Type 1 2 3

sales staff

4.0 a)(5 points)

Parts arrive at a machine shop with EXPO(25) interarrival times (all times are in minutes); the first part arrives at time zero. The shop has two machines, and arriving parts are assigned to one of the machines by flipping a (fair) coin. Except for the processing times, both machines operate in the same fashion. When a part enters a machine area, it requires operator attention to set up the part on the machine (there is only one operator in the shop). After the part is set up, the machine can process it without the operator. Upon completion of the processing, the operator is once again required to remove the part. After completion, the parts exit the system (parts have to go to only one machine). The same operator does all setups and part removals, with priority given to the machine waiting the longest for an operator. The times are (parameters are for triangular distributions):

| Machine Number | Setup Time | Process Time | Removal Time |
|---|---|---|---|
| 1 | 8, 11, 16 | 20, 23, 26 | 7, 9, 12 |
| 2 | 5, 8, 14 | 11, 15, 20 | 4, 6, 8 |

4.0 b) (4 points) describe how to use optoquest to optimize the objective function time in system, when varying resouces 1,2 and resource 3 which has capacities of 1 to 5.

5.0 (5 points) The sequences are already defined as sequences 1 -4 the travelling distances between the different stations take 1 mins use route to model the system

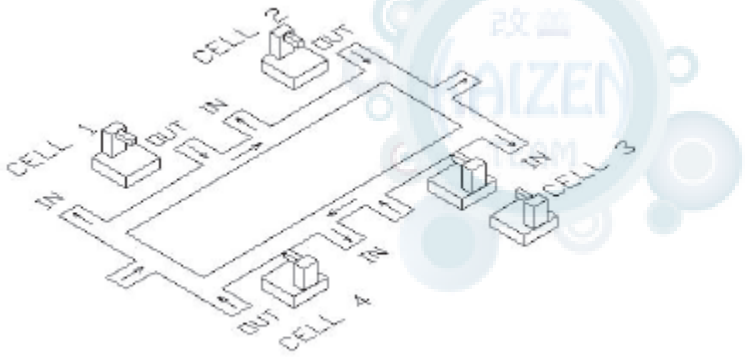
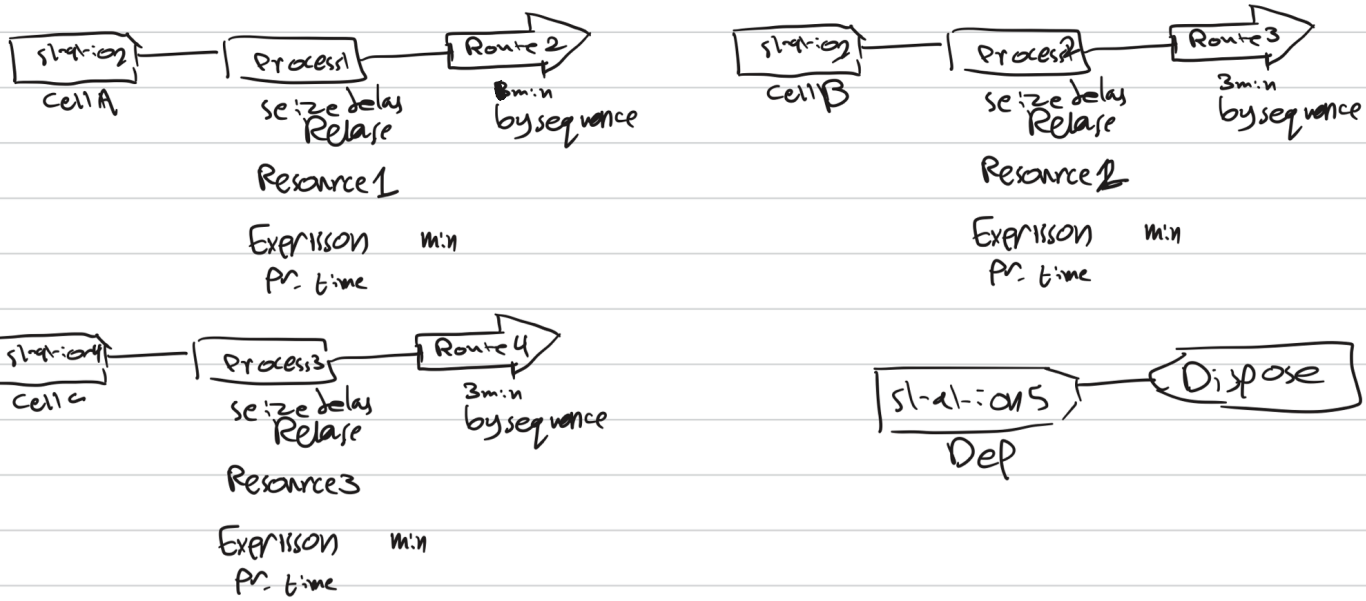



*Figure 7-1. The Small Manufacturing System Layout*

*Table 7-1. Part Routings and Process Times*

| Part Type | Cell/Time | Cell/Time | Cell/Time | Cell/Time | Cell/Time |
|---|---|---|---|---|---|
| 1 | 1<br>6, 8, 10 | 2<br>5, 8, 10 | 3<br>15, 20, 25 | 4<br>8, 12, 16 | |
| 2 | 1<br>11, 13, 15 | 2<br>4, 6, 8 | 4<br>15, 18, 21 | 2<br>6, 9, 12 | 3<br>27, 33, 39 |
| 3 | 2<br>7, 9, 11 | 1<br>7, 10, 13 | 3<br>18, 23, 28 | | |



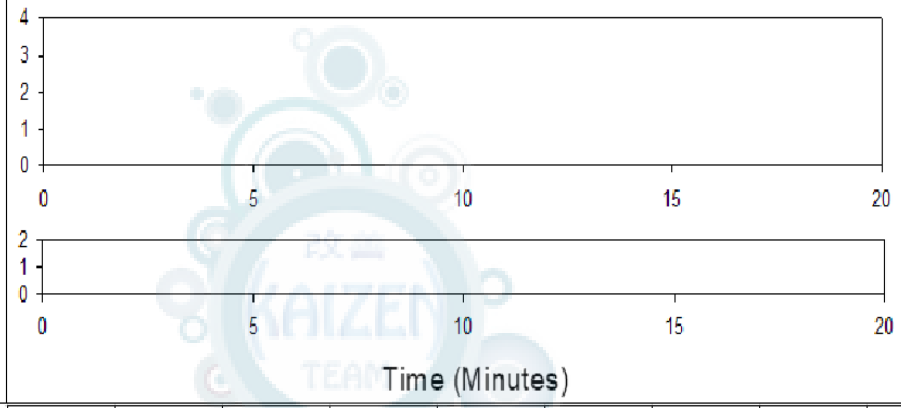

1

1.0 a) Solve the following using hand simulation (4 points)

| System | Clock | $B(t)$ | $Q(t)$ | Arrival times of custs. in queue | Event calendar |
|---|---|---|---|---|---|
| Number of completed waiting times in queue | Total of waiting times in queue | | Area under $Q(t)$ | | Area under $B(t)$ |

$Q(t)$ graph

$B(t)$ graph




| Interarrival times | 0.69 | 1.87 | 8.56 | 11.59 | 3.93 | 5.90 | 3.14 | 7.38 | 6.99 |
|---|---|---|---|---|---|---|---|---|---|
| Service times | 3.57 | 5.39 | 1.53 | 1.44 | 11.08 | 3.76 | 3.06 | 8.91 | 1.90 |

1.0 b)Using linear congruential technique generate next three random numbers ([0-1]) parameters a=11 , c=34 m=101 X0=71 (3 points)

1.0 c) For the rand numbers [0,0.1] {0.107, 0.312 0.715] generate exponential distribution random numbers with mean (1/λ) = 5 (3 points)

2.0 a) What are these arena symbols ( 2 points)

| | | | |
|---|---|---|---|
|  Set | set: define a group of resources | Batch Run (No Animation) | run batch fast No Animation will be visiable |

2.0 (5 points) An acute-care facility treats non-emergency patients (cuts, colds, etc.). Patients arrive according to an exponential interarrival-time distribution with a mean of 11 (all times are in minutes). Upon arrival they check in at a registration desk staffed by a single nurse. Registration times follow a triangular distribution with parameters 6, 10, and 19. After completing registration, they wait for an available examination room; there are three identical rooms. Data show that patients can be divided into two groups with regard to different examination times. The first group (55% of patients) has service times that follow a triangular distribution with parameters 14, 22, and 39. The second group (45%) has triangular service times with parameters 24, 36, and 59. Upon completion, patients are sent home. Model using arena simulation




3.0 (5 points) model the call center with the following specs:

One phone number for customers to call in to 26 trunk lines, one needed for each call (incoming or outgoing, talking or on hold) Arriving call finding no free trunk lines gets busy signal, goes away Count number of such rejected calls Calls arrive with interarrivals ~ EXPO (0.857) min. First call arrives at time 0 Three incoming call types Initial recording to decide ~ UNIF (0.1, 0.6) min. Tech support (76%), sales (16%), order status (8%) Tech-support calls For product type 1 (25%), 2 (34%), or 3 (41%) Needs qualified tech-support person Two for type 1, three for type 2, three for type Separate FIFO queues for each type Conversation time ~ TRIA (3, 6, 18) min. for all types Then leaves system

Sales calls All the same Four sales staff, all the same One FIFO queue feeding all sales staff Conversation time ~ TRIA (4, 15, 45) Then leaves system

4.0 a) (5 points) Develop a model of a three-workstation serial production line with high reject rates: 7% after each workstation. Parts rejected after the fi rst workstation are sent to scrap. Parts rejected after the second workstation are returned to the fi rst workstation where they are reworked, which requires a fresh “draw” from the processing-time distribution but increased by 50% from the distribution of the original operation. (This penalty factor of 1.5 applies only at workstation 1 and not at workstation 2 when the part returns to it.) Parts rejected at the third workstation are returned to the second workstation where they are reworked, with a 50% penalty there (but not on its revisit to workstation 3). The operation times are TRIA(5,9, 12), TRIA(5, 8.5, 13), and TRIA(6.5, 8.9, 12.5) for workstations 1, 2, and 3 respectively (all times are in minutes). Part interarrival times to the system are UNIF(6, 14). Model using arena

4.0 b) (4 points) illustrate how to use PAN software to compare between the use of two resource capacities in relation to work in process and time in system for entity1

5.0 (5 points) Define the sequences for the following system

5.0 (5 points) Define the sequences for the following system

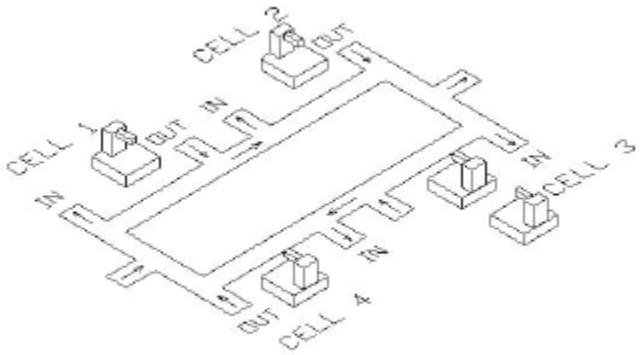



*Figure 7-1. The Small Manufacturing System Layout*

*Table 7-1. Part Routings and Process Times*

| Part Type | Cell/Time | Cell/Time | Cell/Time | Cell/Time | Cell/Time |
|---|---|---|---|---|---|
| 1 | 1<br>6, 8, 10 | 2<br>5, 8, 10 | 3<br>15, 20, 25 | 4<br>8, 12, 16 | |
| 2 | 1<br>11, 13, 15 | 2<br>4, 6, 8 | 4<br>15, 18, 21 | 2<br>6, 9, 12 | 3<br>27, 33, 39 |
| 3 | 2<br>7, 9, 11 | 1<br>7, 10, 13 | 3<br>18, 23, 28 | | |

6.0 (4 points) Describe how to display a message box with a text box to read it and then change the variable value in the arena model, then run it (automatically)

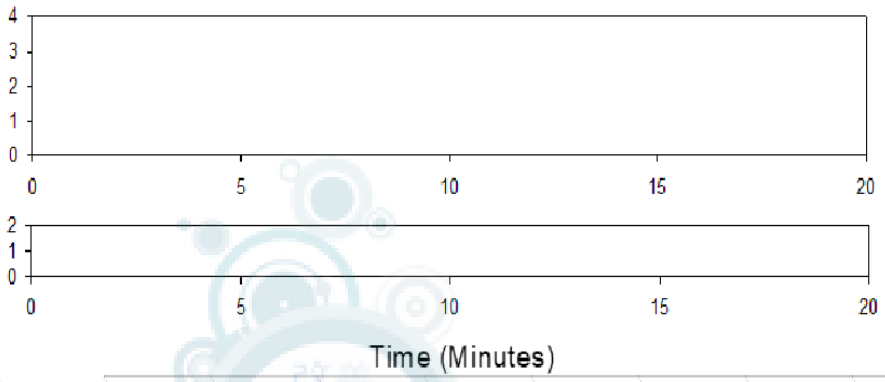

3

1.0 a) Solve the following using hand simulation (4 points)

| System | Clock | $B(t)$ | $Q(t)$ | Arrival times of custs. in queue | Event calendar |
|---|---|---|---|---|---|
| Number of completed waiting times in queue | Total of waiting times in queue | | Area under $Q(t)$ | | Area under $B(t)$ |

$Q(t)$ graph

$B(t)$ graph




| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Interarrival times | 1.83 | 5.43 | 2.46 | 2.97 | 5.98 | 6.07 | 1.78 | 6.99 | 1.78 |
| Service times | 2.39 | 7.16 | 3.32 | 1.78 | 2.77 | 1.87 | 8.00 | 1.98 | 1.78 |

1.0 b)Using linear congruential technique generate next three random numbers ([0-1]) parameters a=7 , c=113 m=111 X0=81 (3 points)

1.0 c) For the rand numbers [0,0.1] {0.507, 0.112 0.615] generate exponential distribution random numbers with mean (1/λ) = 5 (3 points)

2.0 a) What are these arena symbols ( 2 points)

| | | | |
|---|---|---|---|
| In the model<br>- And + | Zoom in<br>out | square shaped button | Stop<br>Run |

2.0 b) (5 points) An acute-care facility treats non-emergency patients (cuts, colds, etc.). Patients arrive according to an exponential interarrival-time distribution with a mean of 11 (all times are in minutes). Upon arrival they check in at a registration desk staffed by a single nurse. Registration times follow a triangularn distribution with parameters 6, 10, and 19. The patient goes to the doctors for 5 mins then 40% of patients go to exam room then go back to doctor take tria(5,6,7) minutes. 60% of the patients just leave.




3.0 (5 points) model the call center with the following specs:

One phone number for customers to call in to 26 trunk lines, one needed for each call (incoming or outgoing, talking or on hold) Arriving call finding no free trunk lines gets busy signal, goes away Count number of such rejected calls Calls arrive with interarrivals ~ EXPO (0.857) min.

First call arrives at time 0 Three incoming call types Initial recording to decide ~ UNIF (0.1, 0.6) min.

Tech support (76%), sales (16%), order status (8%) Tech-support calls For product type 1 (25%), 2 (34%), or 3 (41%) Needs qualified tech-support person Two for type 1, three for type 2, three for type Separate FIFO queues for each type Conversation time ~ TRIA (3, 6, 18) min. for all types Then leaves system

Sales calls All the same Four sales staff, all the same One FIFO queue feeding all sales staff Conversation time ~ TRIA (4, 15, 45) Then leaves system

4.0 a)(5 points) Trucks arrive with EXPO(9.1) interarrival times (all times are in minutes) to an unload area that has three docks; the fi rst truck arrives at time 0. The unload times are TRIA(25, 28, 30), TRIA(23, 26, 28), and TRIA(22, 25, 27) for docks 1, 2, and 3, respectively. If there is an empty dock, the truck proceeds immediately to that dock. Assume zero travel times to all docks. If there is more than one empty dock, the truck places preference on the higher-numbered dock (3, 2, 1). If all the docks are busy, it chooses the dock with the minimum number of trucks waiting. If there is a tie, it places preference on the lowest numbered dock (1, 2, 3). Note that in “by Condition” Decide modules, the tests are done from top to bottom, and the fi rst one resulting in a “true” sends the entity out through that corresponding exit point. Model using arena

4.0 b) (4 points) Describe how to use output analyser to obtain the confidence interval for two alternatives to compare them.

5.0 (5 points) The sequences are already defined as sequences 1 -4 There are two units of transportation cart 1 and two the distances is the same between all stations, travelling between station sis via the transporter model the system.

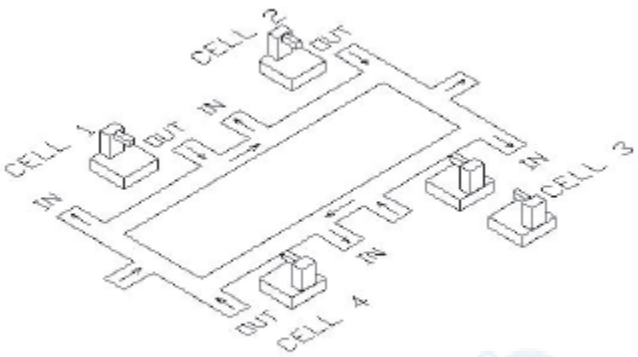



*Figure 7-1. The Small Manufacturing System Layout*

*Table 7-1. Part Routings and Process Times*

| Part Type | Cell/Time | Cell/Time | Cell/Time | Cell/Time | Cell/Time |
|---|---|---|---|---|---|
| 1 | 1<br>6, 8, 10 | 2<br>5, 8, 10 | 3<br>15, 20, 25 | 4<br>8, 12, 16 | |
| 2 | 1<br>11, 13, 15 | 2<br>4, 6, 8 | 4<br>15, 18, 21 | 2<br>6, 9, 12 | 3<br>27, 33, 39 |
| 3 | 2<br>7, 9, 11 | 1<br>7, 10, 13 | 3<br>18, 23, 28 | | |

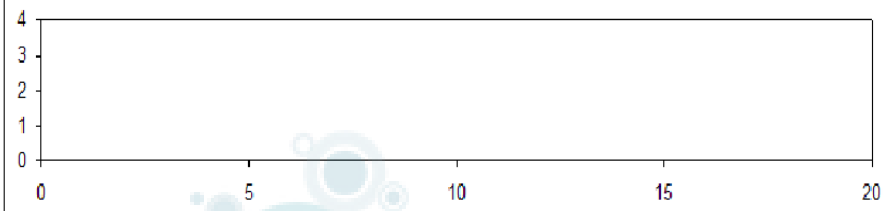
6.0 (4 points) We have an array named SS1 of size 10 x 1 the data should be initialized from microsoft access suitable range describe how this can be done.


4

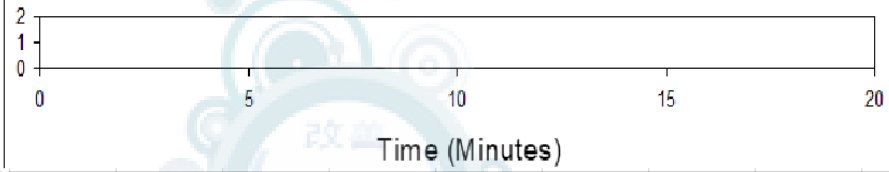
1.0 a) Solve the following using hand simulation (4 points)

| System | Clock | $B(t)$ | $Q(t)$ | Arrival times of custs. in queue | Event calendar |
|---|---|---|---|---|---|
| Number of completed waiting times in queue | Total of waiting times in queue | | Area under $Q(t)$ | | Area under $B(t)$ |

$Q(t)$ graph




$B(t)$ graph




Time (Minutes)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Interarrival times | 3.58 | 1.78 | 4.07 | 7.93 | 1.78 | 6.30 | 4.79 | 1.78 | 1.78 |
| Service times | 1.78 | 1.78 | 1.78 | 1.78 | 1.78 | 1.78 | 1.78 | 5.84 | 1.78 |

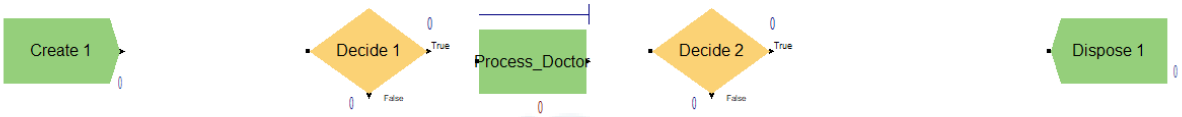
1.0 b)Using linear congruential technique generate next three random numbers ([0-1]) parameters a=37 , c=13 m=91 X0=76 (3 points)

1.0 c) For the rand numbers [0,0.1] {0.907, 0.012 0.275] generate exponential distribution random numbers with mean (1/λ) = 5 (3 points)

Q2) a) What are these arena symbols ( 2 points)

| | | | |
|---|---|---|---|
|   | Macros: Record, Run, Edit macros Scripts |  | Charts display real time graph |

2.0 b) (5 points) An acute-care facility treats non-emergency patients (cuts, colds, etc.). Patientsmarrive according to an exponential interarrival-time distribution with a mean of 11 (all times are in minutes). Upon arrival they check in at a registration desk staffed by a single nurse. Registration times follow a triangular distribution with parameters 6, 10, and 19. Patients go to doctor take tria(5,7,10) then 80% of the patients leave, 20% of the patients go back to registriation to take new appointment take 2 tria(1,2,3) mins then leave




3.0 (5 points) model the call center with the following specs:

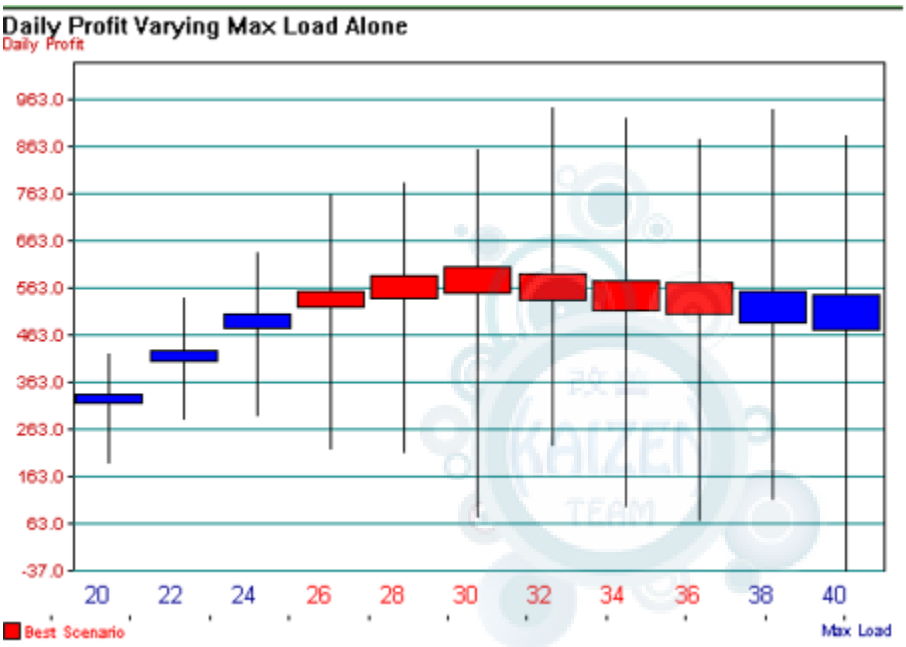
One phone number for customers to call in to 26 trunk lines, one needed for each call (incoming or outgoing, talking or on hold) Arriving call finding no free trunk lines gets busy signal, goes away Count number of such rejected calls Calls arrive with interarrivals ~ EXPO (0.857) min. First call arrives at time 0 Three incoming call types Initial recording to decide ~ UNIF (0.1, 0.6) min.

Tech support (76%), sales (16%), order status (8%) Tech-support calls For product type 1 (25%), 2 (34%), or 3 (41%) Needs qualified tech-support person Two for type 1, three for type 2, three for type Separate FIFO queues for each type Conversation time ~ TRIA (3, 6, 18) min. for all types Then leaves system Sales calls All the same Four sales staff, all the same One FIFO queue feeding all sales staff Conversation time ~ TRIA (4, 15, 45) Then leaves system

4.0 a) (5 points) Parts arrive at a two-machine system according to an exponential interarrival distribution with mean 20 minutes; the fi rst arrival is at time 0. Upon arrival, the parts are sent to Machine 1 and processed. The processing-time distribution is TRIA(4.5, 9.3, 11) minutes. The parts are then processed at Machine 2 with a processing-time distribution as TRIA(16.4, 19.1, 20.8) minutes. The parts from Machine 2 are directed

back to Machine 1 to be processed a second time (same processing-time distribution as the first visit but an independent draw from it). The completed parts then exit the system. Model using arena

4.0 b)(4 points) describe how to use use PAN to generate the following chart from different scenarios start by defining the scenarions with variable resource capacities



5.0 (5 points) The sequences are already defined as sequences 1 -4. Now there is a conveyor loop that goes from the arrival station to cell 1 cell2 depart then cell4 then cell3 then arrival distances is the same assume 5 units, model sing arena

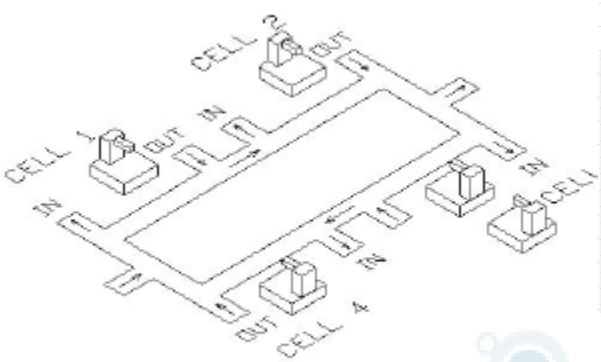
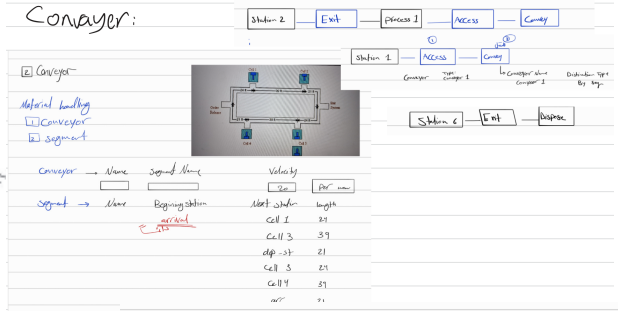



Figure 7-1. The Small Manufacturing System Layout



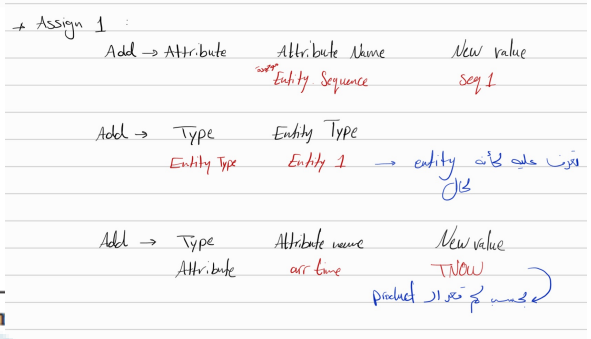
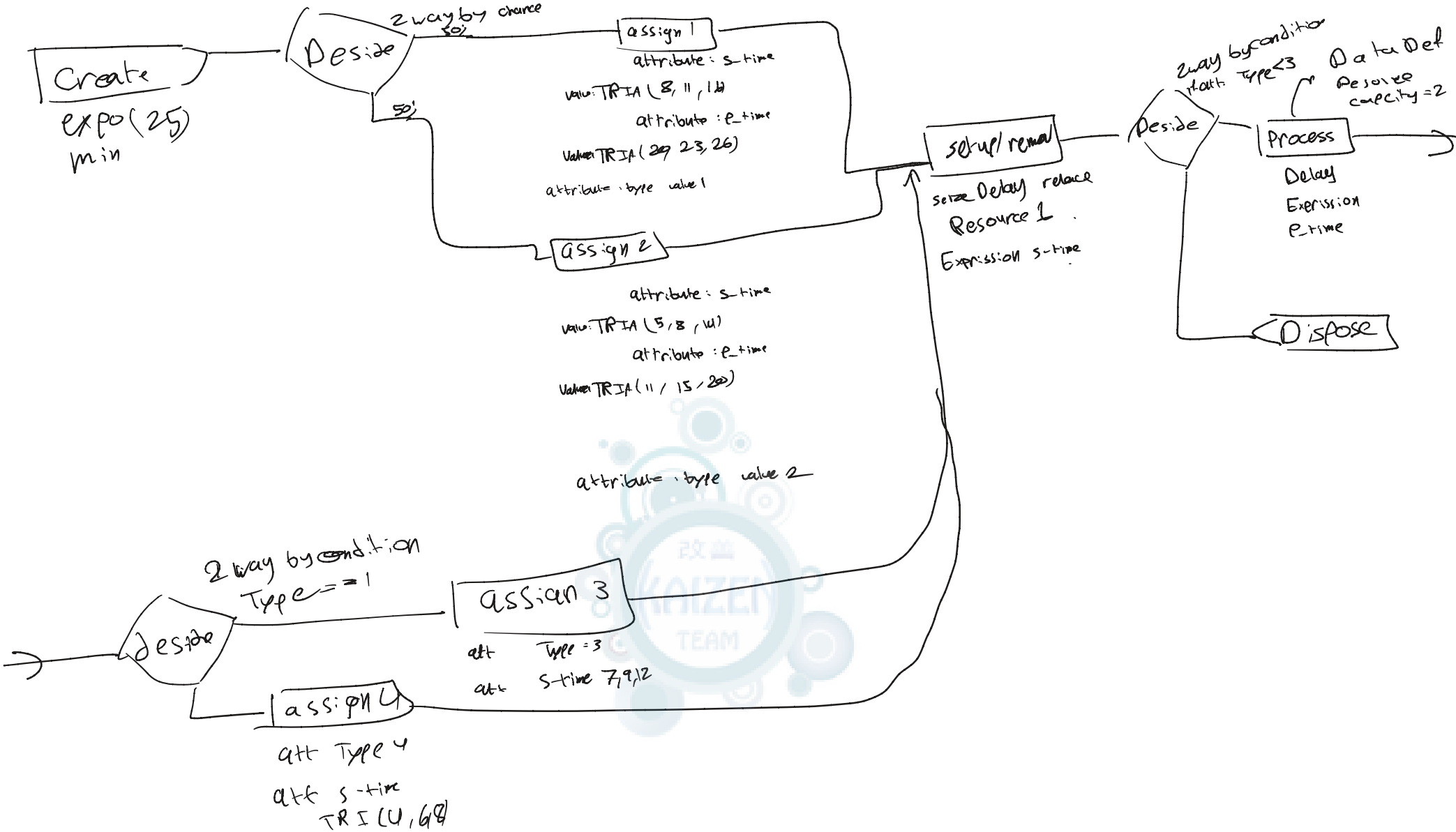




Table 7-1. Part Routings and Process Times

| Part Type | Cell/Time | Cell/Time | Cell/Time | Cell/Tin | |
|---|---|---|---|---|---|
| 1 | 1<br>6, 8, 10 | 2<br>5, 8, 10 | 3<br>15, 20, 25 | 4<br>8, 12, 16 | |
| 2 | 1<br>11, 13, 15 | 2<br>4, 6, 8 | 4<br>15, 18, 21 | 2<br>6, 9, 12 | 3<br>27, 33, 39 |
| 3 | 2<br>7, 9, 11 | 1<br>7, 10, 13 | 3<br>18, 23, 28 | | |

Assign 2/3

6.0 (4 points) We have a variable array named DD1 of size 5 x 6 we need to initalise it from excel of suitable range.


Create
expo(25)
min
Desize
2 way by chance
50%
50%
assign 1
attribute : s_time
value: TRIA (8, 11, 16)
attribute : e_time
Value: TRIA (20, 23, 26)
attribute : byte value 1
assign 2
attribute : s_time
value: TRIA (5, 8, 11)
attribute : e_time
Value: TRIA (11, 15, 20)
attribute : byte value 2
setup/ remove
setup Delay release
Resource 1
Expression s-time
Desize
2way by condition
Att: Type<3
Process
Data Def
Resource
capcity = 2
Delay
Expression
e_time
Dispose
Desize
2 way by condition
Type == 1
assign 3
att Type = 3
att s-time 7, 9, 12
assign 4
att Type 4
att s-time
TRIA (4, 6, 8)

# 4. optquest

Describe how to optimize using optoquest alternative scenarios one with numbers of workers equal to two or three and number of machines 5 or six N in PAN with analysis for Entity. Time in system.

Describe how to optimize using optoquest alternative scenarios one with numbers of workers equal to two or three and number of machines 5 or six N in PAN with analysis for Entity. Time in system.

1.) Tools > optquest

2.) New session (File > new)

Insert 1- controls 2. constraints 3- objective

3.)

Controls

| Name | element type | type | low value | suggested value | high value |
|---|---|---|---|---|---|
| no. worker | resource | integer | 1 | — | 3 |
| no. machines | resource | integer | 5 | — | 6 |

4.)

Constraints

| Name | Expression |
|---|---|
| First | 2 ≤ no. workers ≤ 3 |
| second | 5 ≤ no. machines ≤ 6 |

5.)

Objective

| Name | Goal | Expression |
|---|---|---|
| obj. 1 | Minimize | Entity. Time in system |

6.) ▶ Run

6.0 (4 points) describe how to read arrival data from a sequential file

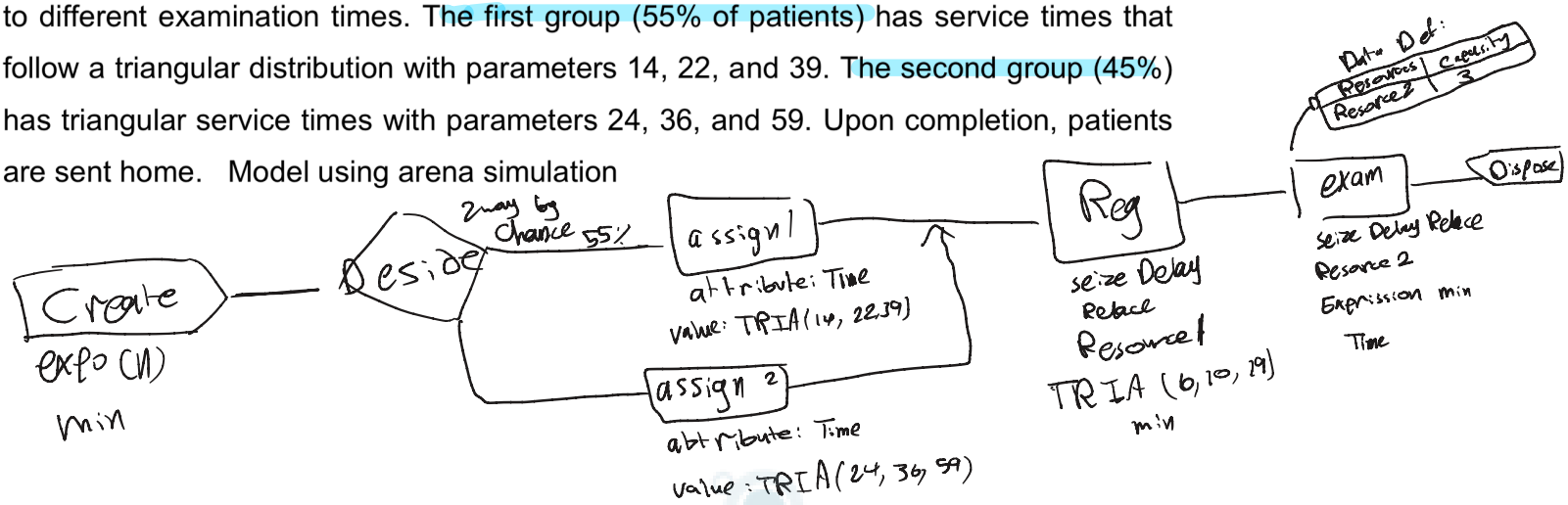
for sequential file no need for Recordset ~~name~~ ID

Explain with a model how to read from sequential File ?

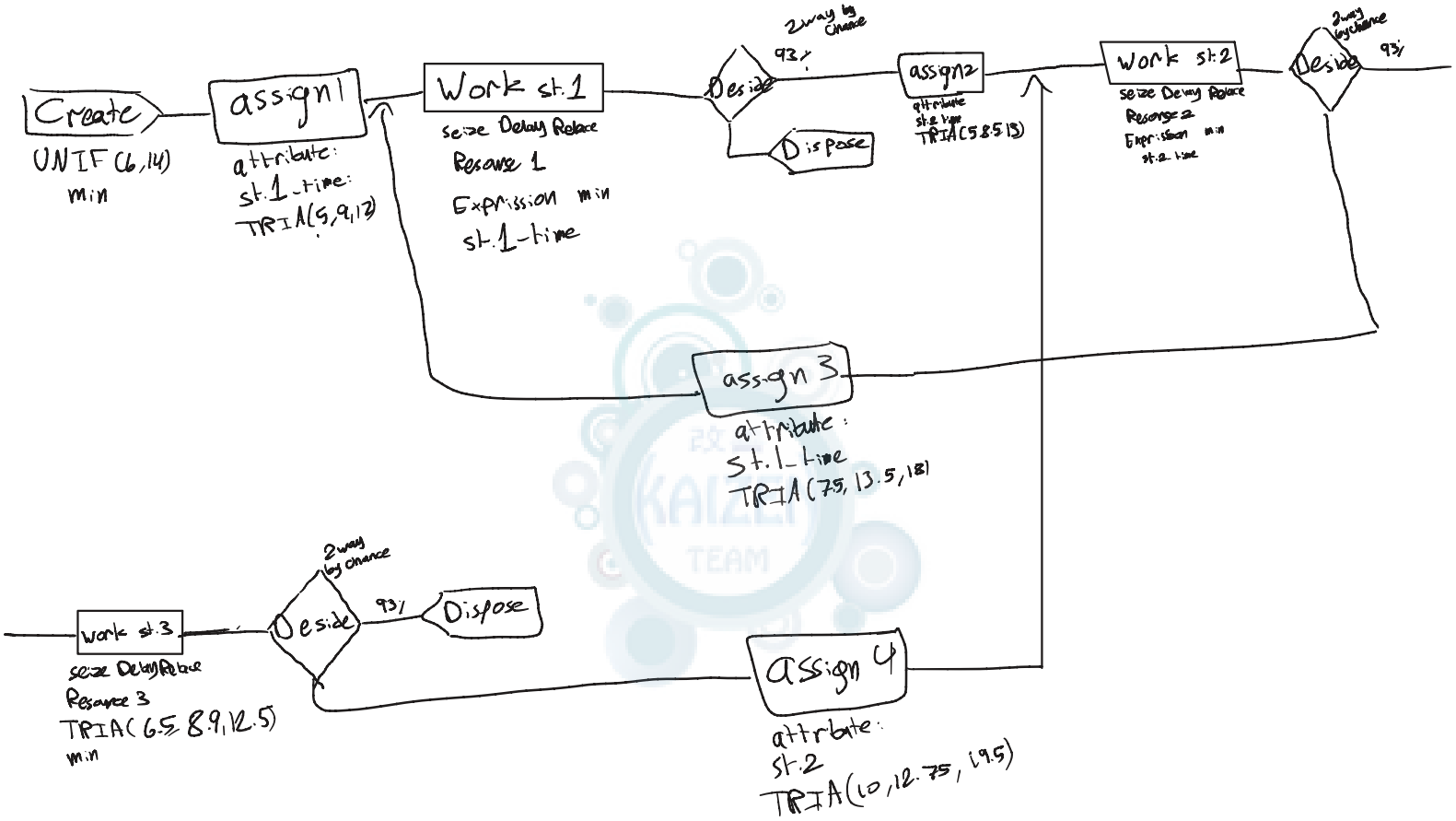
1. an already defined sequential file like notepad files will be us
2. open arena. from output - input define file give it aname.
the access type ( sequential file ). Load the file from your pc.
~~file~~ / end of file Action ( Dispose ).
~~place~~ from in put and output ~~define~~ add read write.
choose the file name , the type read from file ..
add assigments . attribute . ( arrival time ) then ok .

arena object :
1. ~~standard~~ View
2. ~~simulation~~ model
3. application

2.0 (5 points) An acute-care facility treats non-emergency patients (cuts, colds, etc.). Patients arrive according to an exponential interarrival-time distribution with a mean of 11 (all times are in minutes). Upon arrival they check in at a registration desk staffed by a single nurse. Registration times follow a triangular distribution with parameters 6, 10, and 19. After completing registration, they wait for an available examination room; there are three identical rooms. Data show that patients can be divided into two groups with regard to different examination times. The first group (55% of patients) has service times that follow a triangular distribution with parameters 14, 22, and 39. The second group (45%) has triangular service times with parameters 24, 36, and 59. Upon completion, patients are sent home. Model using arena simulation



4.0 a) (5 points) Develop a model of a three-workstation serial production line with high reject rates: 7% after each workstation. Parts rejected after the fi rst workstation are sent to scrap. Parts rejected after the second workstation are returned to the fi rst workstation where they are reworked, which requires a fresh “draw” from the processing-time distribution but increased by 50% from the distribution of the original operation. (This penalty factor of 1.5 applies only at workstation 1 and not at workstation 2 when the part returns to it.) Parts rejected at the third workstation are returned to the second workstation where they are reworked, with a 50% penalty there (but not on its revisit to workstation 3). The operation times are TRIA(5,9, 12), TRIA(5, 8.5, 13), and TRIA(6.5, 8.9, 12.5) for workstations 1, 2, and 3 respectively (all times are in minutes). Part interarrival times to the system are UNIF(6, 14). Model using arena



# 3. PAN

4.0 b) (4 points) illustrate how to use PAN software to compare between the use of two resource capacities in relation to work in process and time in system for entity1

Describe how to Analyze alternative scenarios one with numbers of workers equal to two or three and number of machines 5 or six N in PAN with analysis for Entity. Time in system and system.Number out

(1 = controls, 2 = responses)

Describe how to Analyze alternative scenarios one with numbers of workers equal to two or three and number of machines 5 or six N in PAN with analysis for Entity. Time in system and system.Number out

2 factors [controls] with 2 levels

$2^2 = 4$ scenarios

1. Tools > process Analyzer > New File > Double click > Browse > select scenario 1 properties

2. Insert (add scenario, controls, Responses

| Scenario properties | | controls | | Responses | |
|---|---|---|---|---|---|
| Name | program file | no. workers | no. machines | Entity. Time in system | system. number out |
| First | File.p | 2 | 5 | — | — |
| second | File.p | 2 | 6 | — | — |
| third | File.p | 3 | 5 | — | — |
| fourth | File.p | 3 | 6 | — | — |

3. select all of scenarios

4. Run ▶

For charts select all scenarios the charts

select required chart

Similar Question

Data Def sequance

start at Arr

sequance 1

cell1 Att pr-time TRIA(6,8,10)

cell2 // (5,8,10)

cell3 // (15,20,25)

cell4 (8,12,16)

Dep (11,13,15

sequance 2

cell1 // (4,6,8)

Cell2 (15,18,21)

cell4 (6,9,12)

cell2 // // (27,3,39)

cell3

Dep

sequance3

cell2 (7,9,11)

cell1 // // (7,10,13)

cell3 (15,27,28)

Dep

6.0 (4 points) Describe how to display a message box with a text box to read it and then change the variable value in the arena model, then run it (automatically)

1- Tools > Visual Basic Editor

2- In project : double click "This document"

3- Choose "Model Logic"

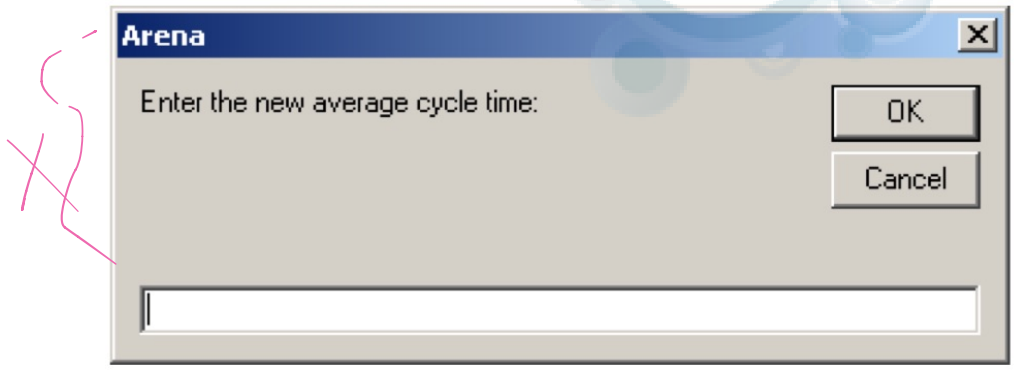
4- Write the code

```
Dim oSIMAN As Arena.SIMAN
Dim nVarIndex As Long
Dim sNewValue As String

' Prompt for a new value
sNewValue = InputBox("Enter the new average cycle time:")

' Assign their answer to the Mean Cycle Time variable
Set oSIMAN = ThisDocument.Model.SIMAN
nVarIndex = oSIMAN.SymbolNumber("Mean Cycle Time")
oSIMAN.VariableArrayValue(nVarIndex) = sNewValue
```

اسم Arena زمان




In this case add this line at the end

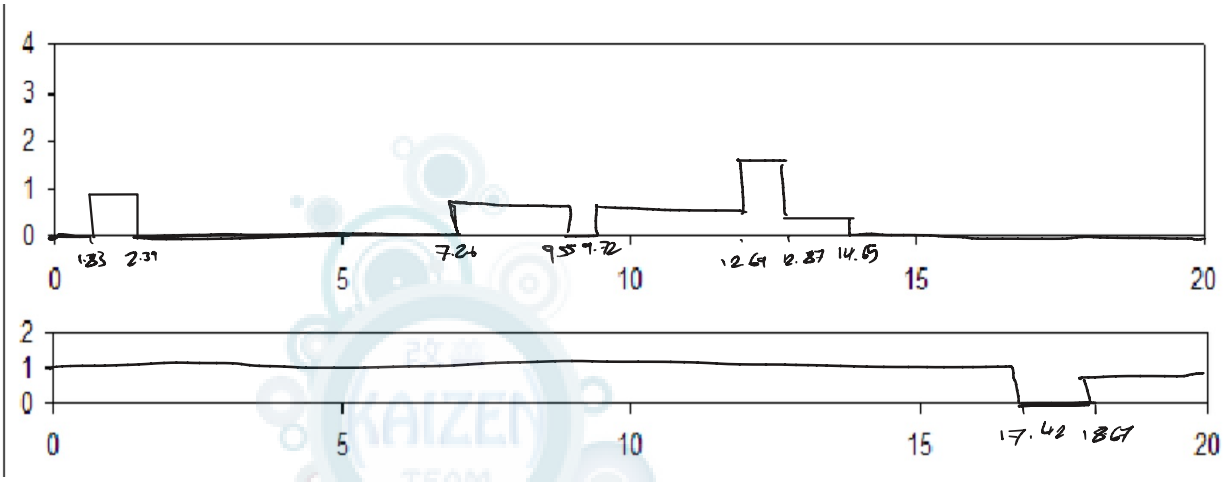
ThisDocument.Model.Go → to have the code run automatically

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Interarrival times | ~~1.83~~ | ~~5.43~~ | ~~2.46~~ | ~~2.97~~ | ~~5.98~~ | ~~6.07~~ | 1.78 | 6.99 | 1.78 |
| Service times | ~~2.39~~ | ~~7.16~~ | ~~3.32~~ | ~~1.78~~ | ~~2.77~~ | 1.87 | 8.00 | 1.98 | 1.78 |

| Arr | Dep | T | Q |
|---|---|---|---|
| 0 | 2.39 | 2.39 | 0 |
| 1.83 | 9.55 | 7.72 | 0.56 |
| 7.26 | 12.87 | 5.51 | 2.29 |
| 9.72 | 14.65 | 4.93 | 3.15 |
| 12.69 | 17.42 | 4.73 | 1.96 |
| 18.67 | 20.54x | 1.87 | 0 |
| ~~24.74~~ | | | |

Q(t) graph

B(t) graph




1.0 b)Using linear congruential technique generate next three random numbers ([0-1]) parameters a=7 , c=113 m=111 X0=81 (3 points)

$X_1 = 7 \times 81 + 113 \bmod 111 = 14$ $\quad R_1 = 0.126$

$X_2 = 7 \times 14 + 113 \bmod 111 = 100$ $\quad R_2 = 0.9009$

$X_3 = 7 \times 100 + 113 \bmod 111 = 36$ $\quad R_3 = 0.324$

1.0 c) For the rand numbers [0,0.1] {0.507, 0.112 0.615] generate exponential distribution random numbers with mean (1/λ) = 5 (3 points)

$X_i = \frac{-1}{\lambda} \ln(1 - R_i)$

$X_1 = -5 \ln(1 - 0.507) = 3.536$

$X_2 = 0.5939$

$X_3 = 4.77$

4.0 b) (4 points) Describe how to use output analyser to obtain the confidence interval for two alternatives to compare them.

## 2.] output analyzer

↳ operates on (.dat) files produced by arena

↳ input/output panel > output > Expression , Name , output File

---

Describe how in one of arena components we can compare between the mean of two alternatives and find the confidence internal for both and plot that confidence interval

output.

---

Describe how in one of arena components we can compare between the mean of two alternatives and find the confidence internal for both and plot that confidence interval

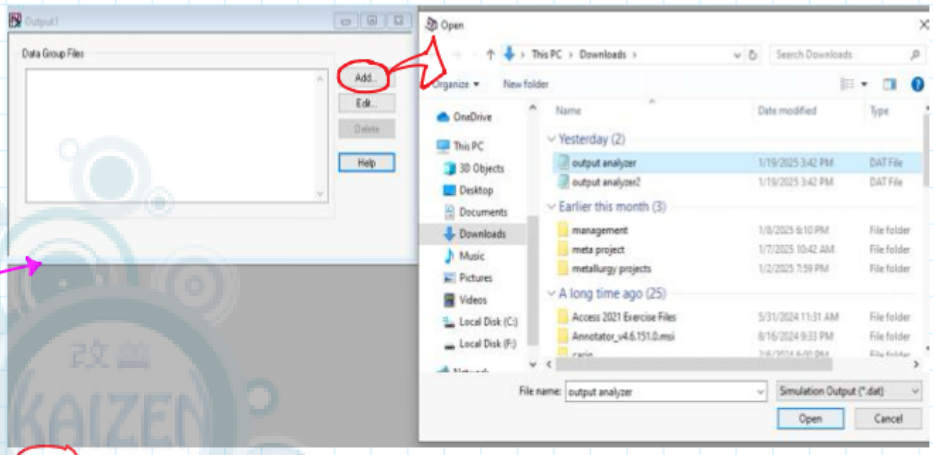
(output)

1.] we made run (one replication) of both alternatives.

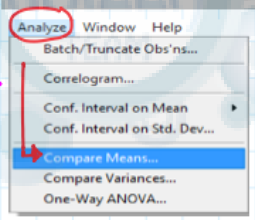
2.] Window > output analyzer

3.] open new "data group files"

4.] Add > select files of interest




5.] Analyze > compare means



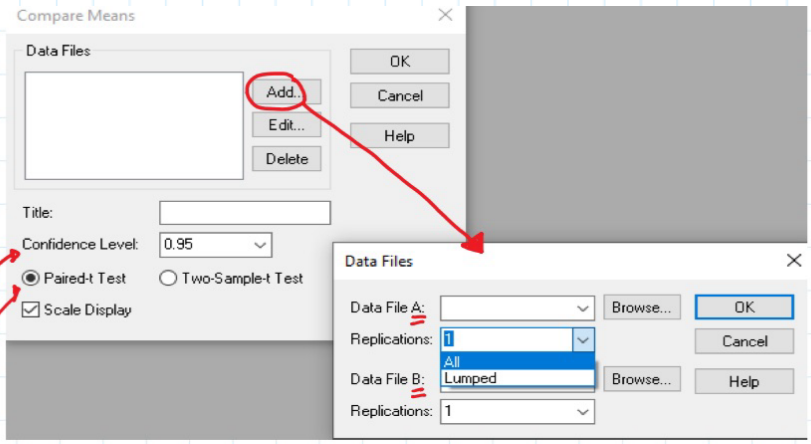

6.] ADD > Data Files

Data File A : Alternative1.dat

Replications: Lumped

Data File B : Alternative2.dat

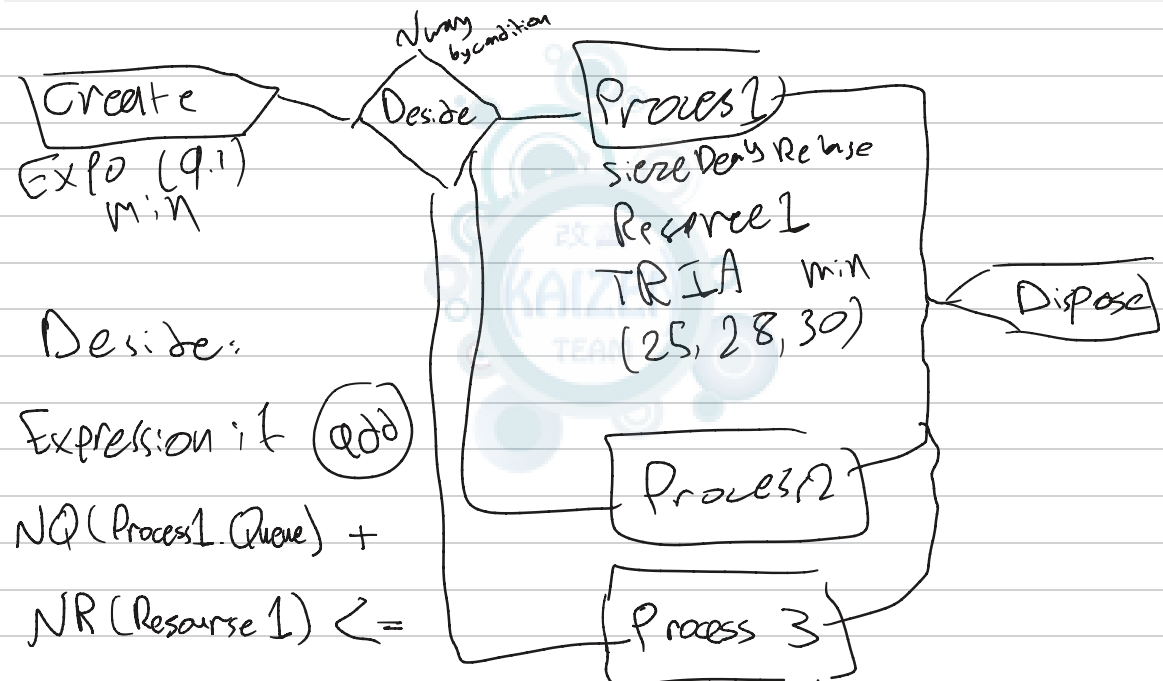
Replications: Lumped




7.] * paired t-test

* confidence level : 0.95

4.0 a)(5 points) Trucks arrive with EXPO(9.1) interarrival times (all times are in minutes) to an unload area that has three docks; the first truck arrives at time 0. The unload times are TRIA(25, 28, 30), TRIA(23, 26, 28), and TRIA(22, 25, 27) for docks 1, 2, and 3, respectively. If there is an empty dock, the truck proceeds immediately to that dock. Assume zero travel times to all docks. If there is more than one empty dock, the truck places preference on the higher-numbered dock (3, 2, 1). If all the docks are busy, it chooses the dock with the minimum number of trucks waiting. If there is a tie, it places preference on the lowest numbered dock (1, 2, 3). Note that in "by Condition" Decide modules, the tests are done from top to bottom, and the first one resulting in a "true" sends the entity out through that corresponding exit point. Model using arena




Decide:

Expression if (add)

NQ(Process1.Queue) +

NR(Resourse 1) <=

NQ(Process2.Queue) + NR(Resourse 2) && <=

NQ(Process3.Queue) + NR(Resourse 3)

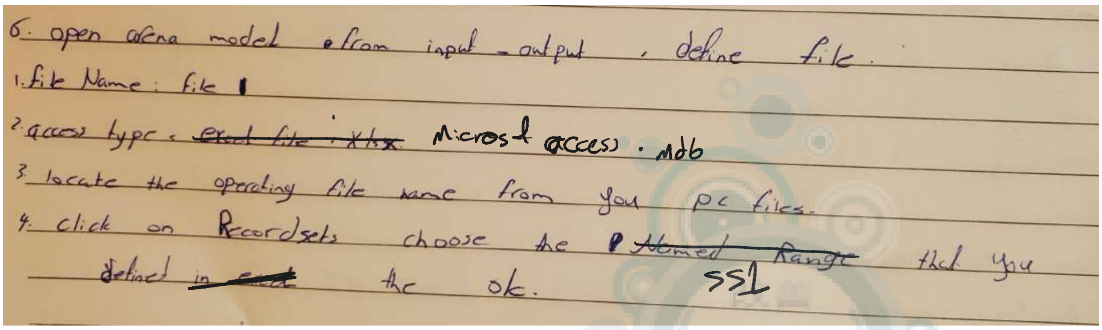
(add) Expression if

NQ(Process2.Queue) + NR(Resourse 2) <=

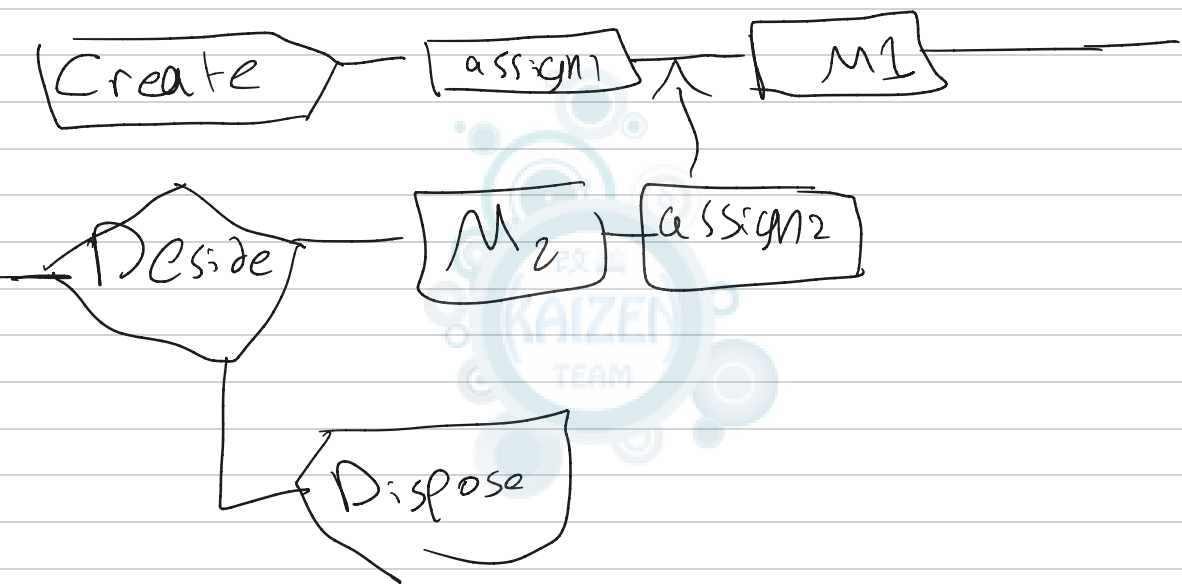
NQ(Process3.Queue) + NR(Resourse 3)

6.0 (4 points) We have an array named SS1 of size 10 x 1 the data should be initialized from microsoft access suitable range describe how this can be done.

1- open Microsoft Access
2- create New Database
3- create Table & add column
4- Enter data, save file
5- In Arena



4.0 a) (5 points) Parts arrive at a two-machine system according to an exponential interarrival distribution with mean 20-minutes; the fi rst arrival is at time 0. Upon arrival, the parts are sent to Machine 1 and processed. The processing-time distribution is TRIA(4.5, 9.3, 11) minutes. The parts are then processed at Machine 2 with a processing-time distribution as TRIA(16.4, 19.1, 20.8) minutes. The parts from Machine 2 are directed back to Machine 1 to be processed a second time (same processing-time distribution as the first visit but an independent draw from it). The completed parts then exit the system. Model using arena




assign1 :

add attribute
name: Type
value 1

assign2 :
add attribute
name Type
value 2

Decide 1 :
2 way by condition
Expression
if attribute Type == 1

# 3. PAN

Describe how to Analyze alternative scenarios one with numbers of workers equal to two or three and number of machines 5 or six N in PAN with analysis for Entity. Time in system and system.Number out

Describe how to Analyze alternative scenarios one with numbers of workers equal to two or three and number of machines 5 or six N in PAN with analysis for Entity. Time in system and system.Number out

2 factors [controls] with 2 levels
$2^2 = 4$ scenarios

1. Tools > process Analyzer > New project > File > New

2. add (doubleclick)

| Scenario | properties |
|---|---|
| Name | program file |
| First | File.p |
| second | File.p |
| third | File.p |
| fourth | File.p |
| 40 | File.p |

Insert controls

| no. workers | Max load ~~no machines~~ |
|---|---|
| 1 | 3 |
| 2 | 20 |
| 3 | 25 |
| 3 | 6 |

Insert Responses

| ~~Entity. Time in System~~ | ~~system. number out~~ Daily profit |
|---|---|
| — | — |
| — | — |
| — | — |
| — | — |

3. select all of scenarios

4. Run

right click
properties
replicate 50 times

5) Insert chart
Box and Whiskers

6.0 (4 points) We have a variable array named DD1 of size 5 x 6 we need to initalise it from excel of suitable range.

Ch 10.

How to initialize an excel variable array ?

1. open an excel file
2. Place your data in an excel column or row (size 5x5) in a sequancial form.
3. Select the cells of the array, then right click, choose
4. "define Name", Name the selected Range, then ok. DD1
5. Save your excel file

open arena model from input - output, define file.

1. file Name: file
2. access type: excel file. Xlsx
3. locate the operating file name from your pc files.
4. click on Recordsets choose the Named Range that you defined in excel the ok. DD1