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	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 هيسوان		
الرقم المتسلسل:	وقت المحاضرة:	رقم الشعبة:	اسم المدرس: أ.د محمود بن غش

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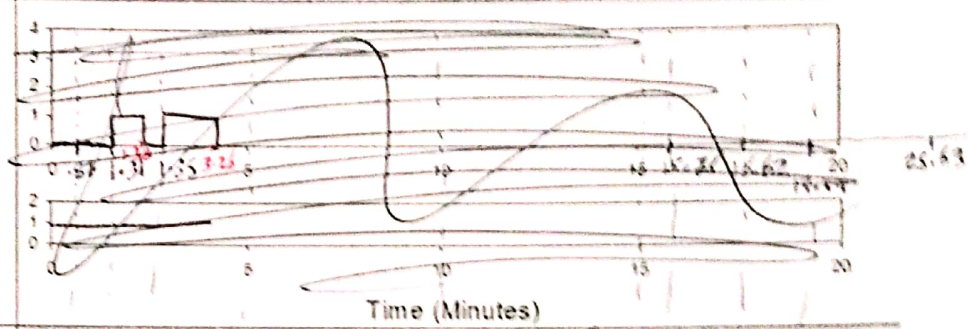
No.	ILO	SO	DL	Mark	Weight
1			2	6	6
2			2	5	6
3			2	6	6
4			2	5	6
5			2	6	6

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

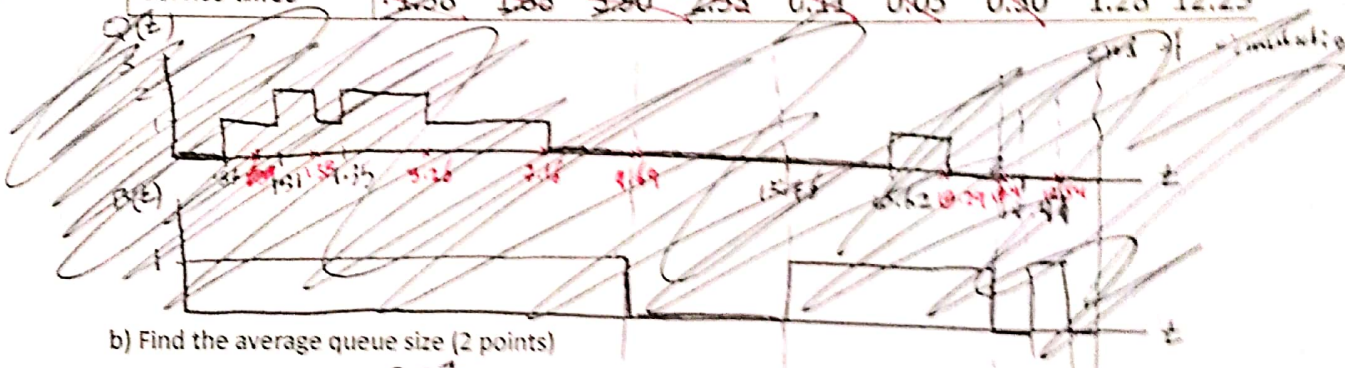
29 | 28 | 30

For Proctor's Remarks

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

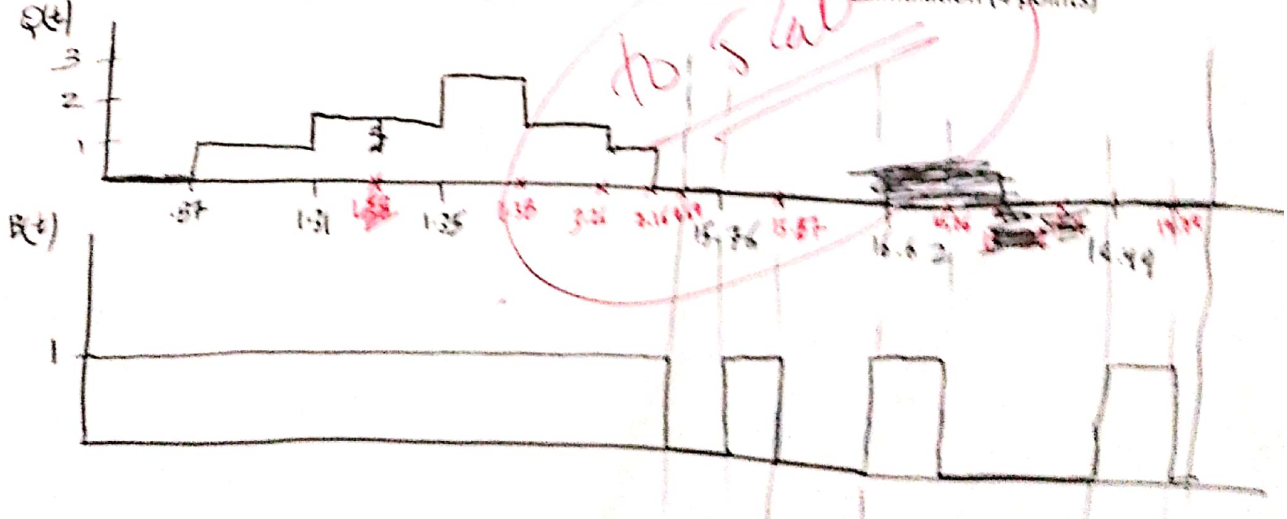
Time (Minutes)



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)



5/6

5/4

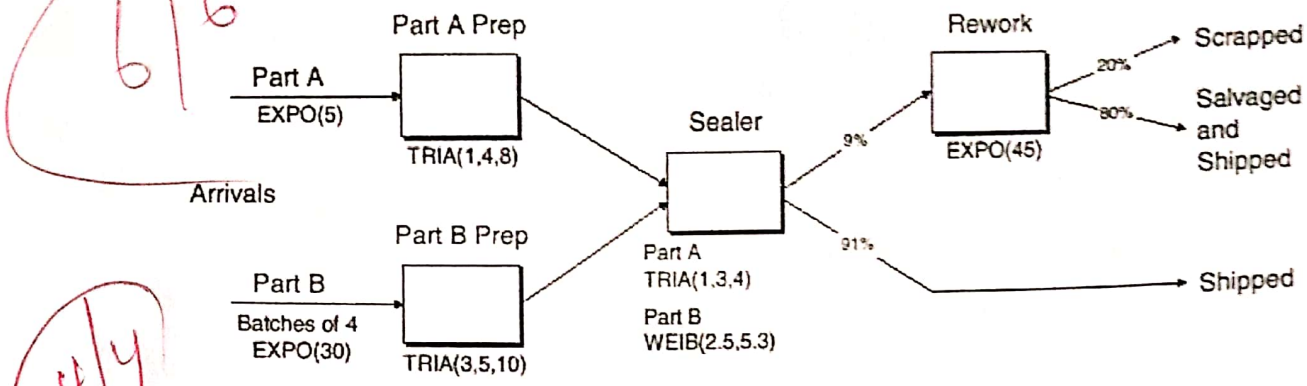
Symbol	meaning	Symbol	Meaning
	Segment		Simulation Animation
	fast forward		connect two block to gether
Number of Replications	repeat the simulation run with different number drawn from the same distribution	Input Analyzer	analysing input distribution
add animation for resource.	(using random number 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)

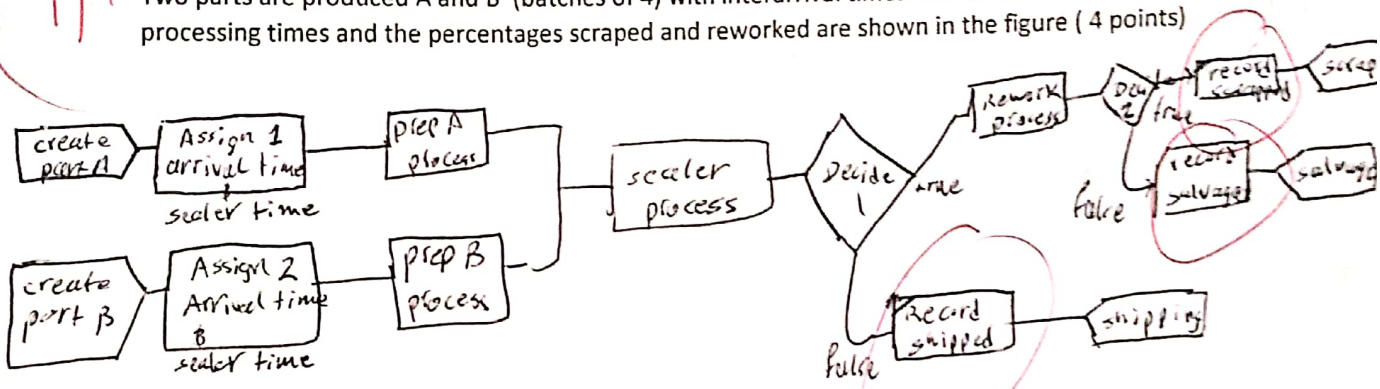
from ~~Resource~~ → animation > resource
→ animation > entity

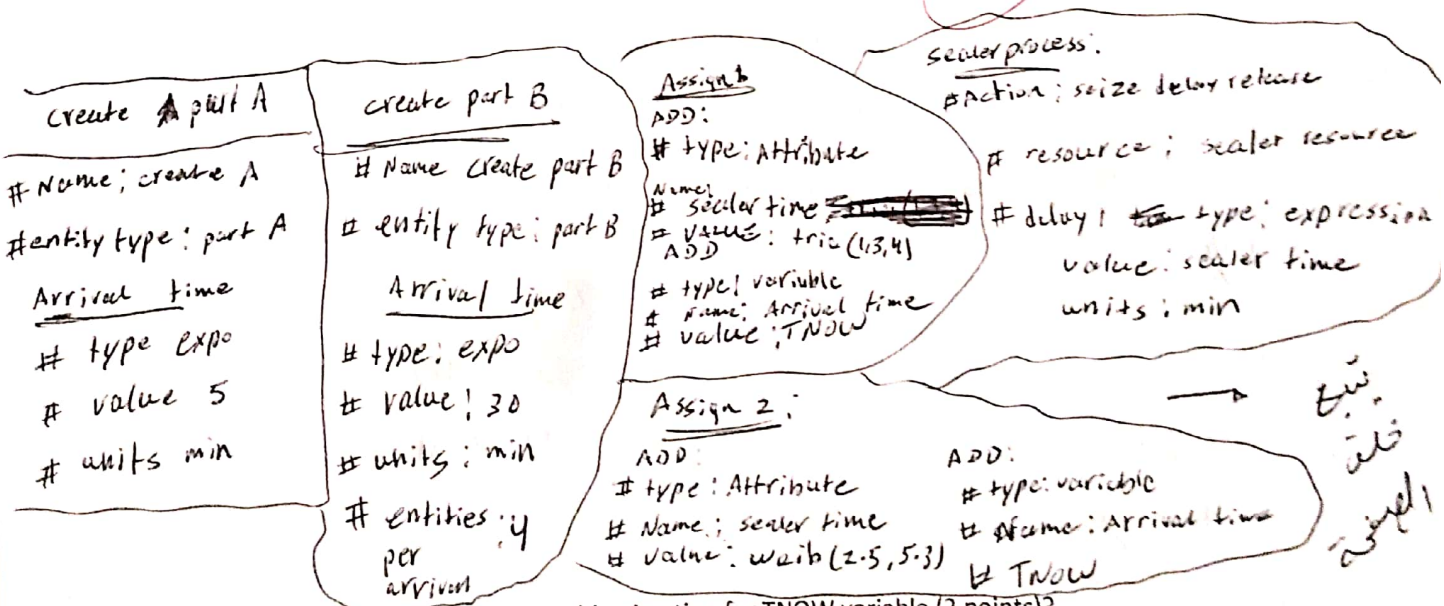
$1 ~

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



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

prop A process:

Action: seize delay release

ADD: resource → resource Name: prop A resource

delay: type → expression

value: tria(4,8)

unit: min

prop B process:

Action: seize delay release

ADD: resource → resource Name: prop B resource

delay: type: expression

value: tria(3,5,10)

units: min

decide 1:

type: 2 way by chance

value → 90%

decide 2:

type: 2 way by chance

value → 20%

rework process:

Action: seize delay release

ADD: resource → resource Name: rework

delay → type: expression

value: expo(45)

units: min.

salvaged

↳ Dispose

↳ Name: salvaged.

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.

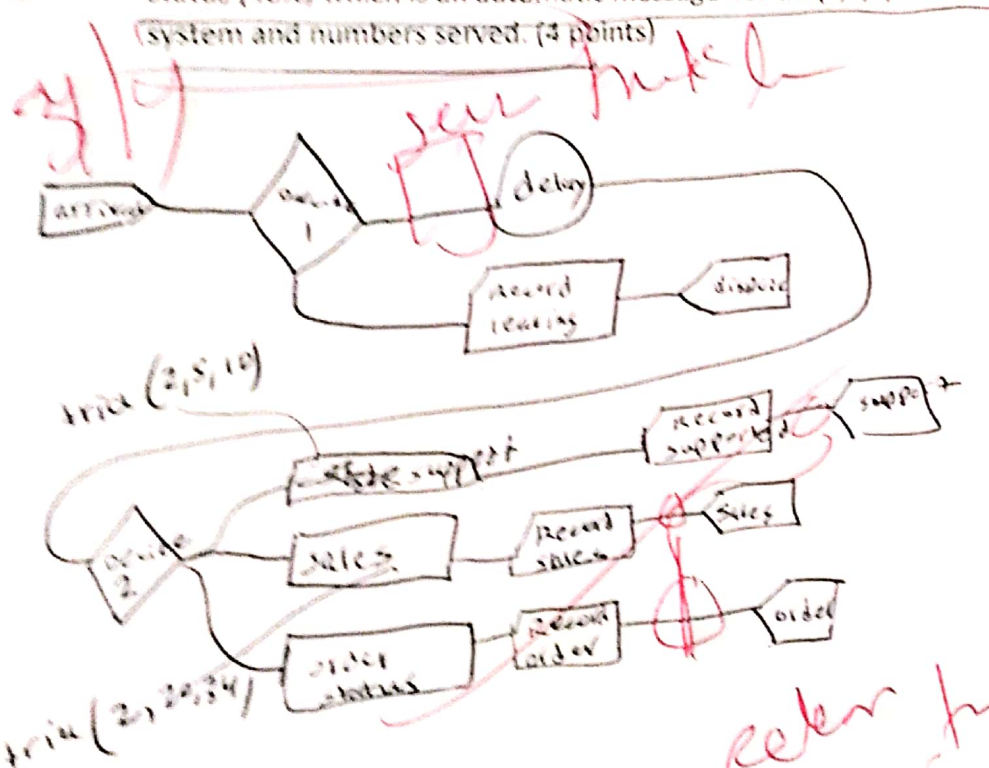
data definition → schedules → support sch.

period	Value
8	2
9	1

period

→ 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

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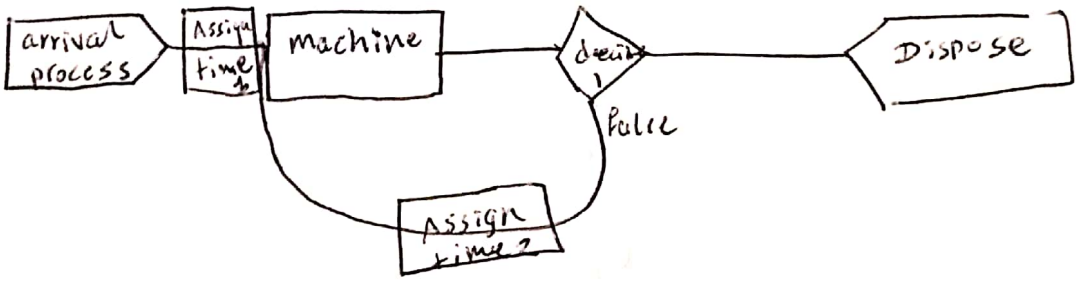
Q5) Parts arrive at a single machine system according to an exponential interarrival distribution with mean 20 minutes; the first part arrives at time 0. Upon arrival, the parts are processed at a machine. The processing-time distribution is TRIA(11, 16, 18) minutes. The parts are inspected and for each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



create arrival process

Name: arrival process

Arrival time:

type: expo

value: 20

units: min

first arrival: 0

Assign time1

type: Attribute

Name: time

value: tria(11,16,18)

Assign time 2

type: Attribute

Name: time

value: tria(11,16,18)

process

#machine

Action: seize delay release

ADD: resource → resource Name: machine 1

#delay: #type: expression

#value: time #units: min

decide

2 way by chance

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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:	اسم الطالب (باللغة العربية):
0215522	محمد عبد القادر أحمد حسني

الرقم المتسلسل:	وقت المحاضرة:	رقم الشعبة:	اسم المدرس: أد محمود برغش

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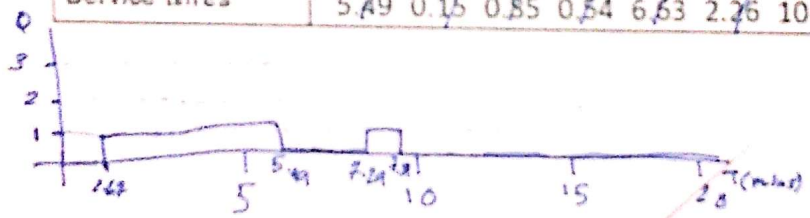
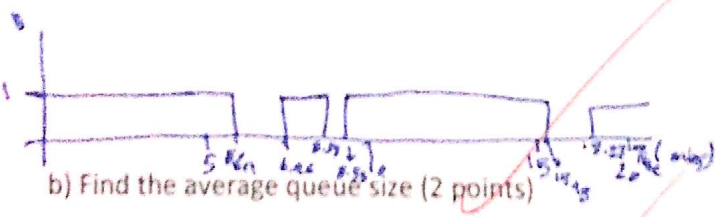
29 30

For Proctor's Remarks

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





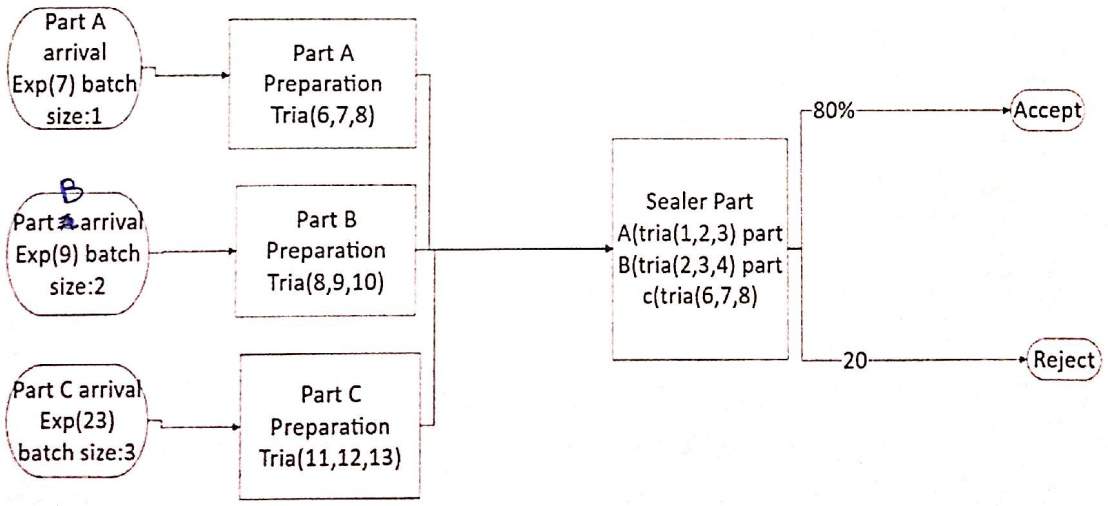
b) Find the average queue size (2 points)

$$\frac{(5.49-2.67)+(7.31-7.24)}{20} = 0.167 \text{ /min.}$$

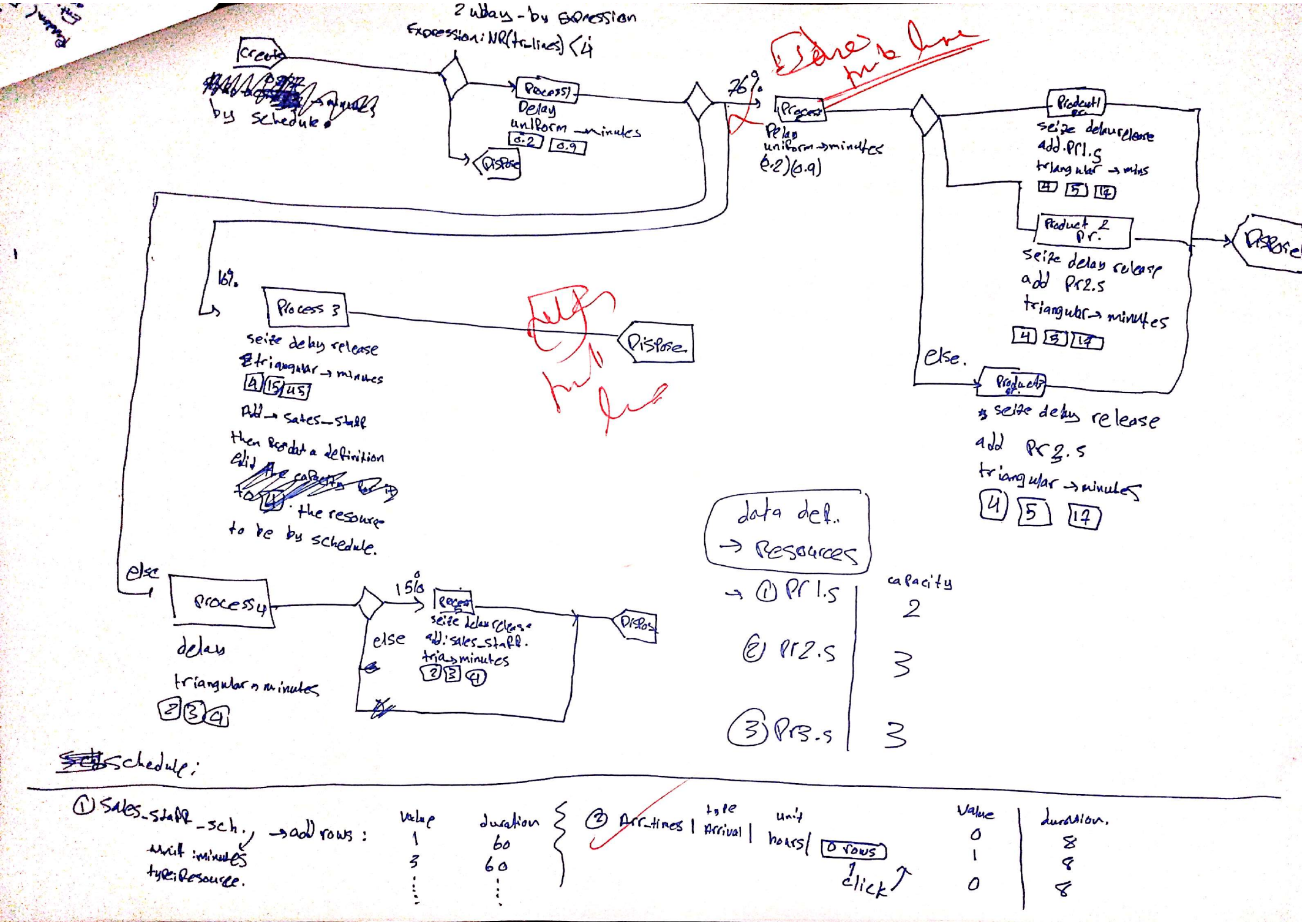
Q2) Find in the meaning of the following symbols in ARENA discrete event simulation (4 points)

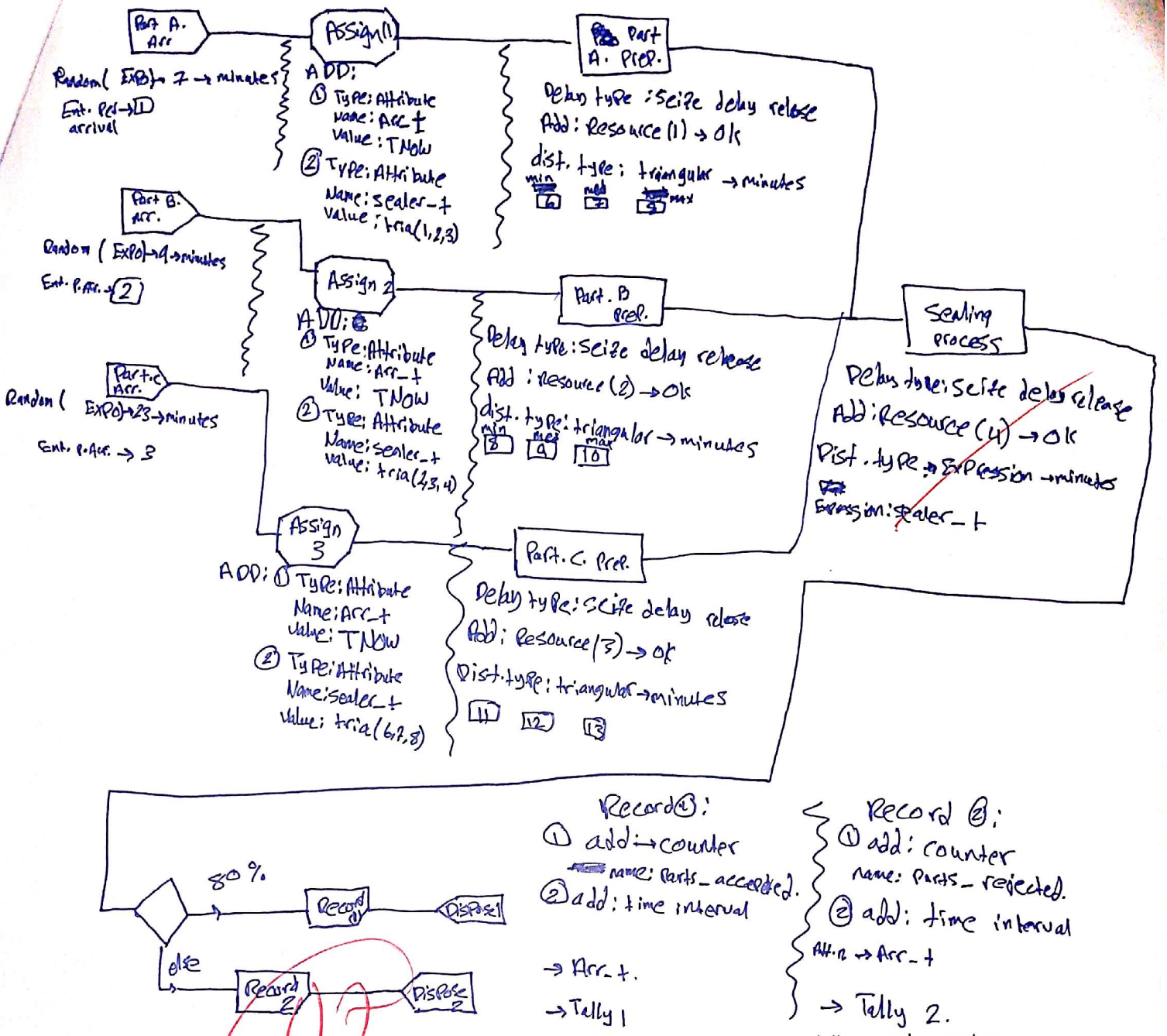
Symbol	meaning
▶	Go, to run the system
Warm-up Period: 00	set the length of warm-up period, which the system won't take the stat in that period (beginning)
Number of Replications: 1	How much repetitive times the system will run
	add a distance animation

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)


2 way - by Expression
Expression: NR(tr_lines) < 4
Create
by schedule
Process1
Delay
uniform → minutes
0.2
0.9
Dispose
76%
Process
Delay
uniform → minutes
(0.2)(0.9)
else
Product1
seize delay release
add Pr1.s
triangular → mins
4
5
14
Product 2 Pr.
seize delay releasr
add Pr2.s
triangular → minutes
4
5
14
Dispose
else.
Product3
seize delay release
add Pr2.s
triangular → minutes
4
5
14
16%
Process 3
seize delay release
triangular → minutes
4
15
45
Add → sales_staff
then Product a definition
Edit
to 4
the resource
to be by schedule.
Dispose
else
Process4
delay
triangular → minutes
2
3
4
15%
Process
seize delay release
add: sales_staff.
tria → minutes
2
3
4
else
Dispos
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
click
Value
0
1
0
duration.
8
8
8



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)

الصفحة السابقة

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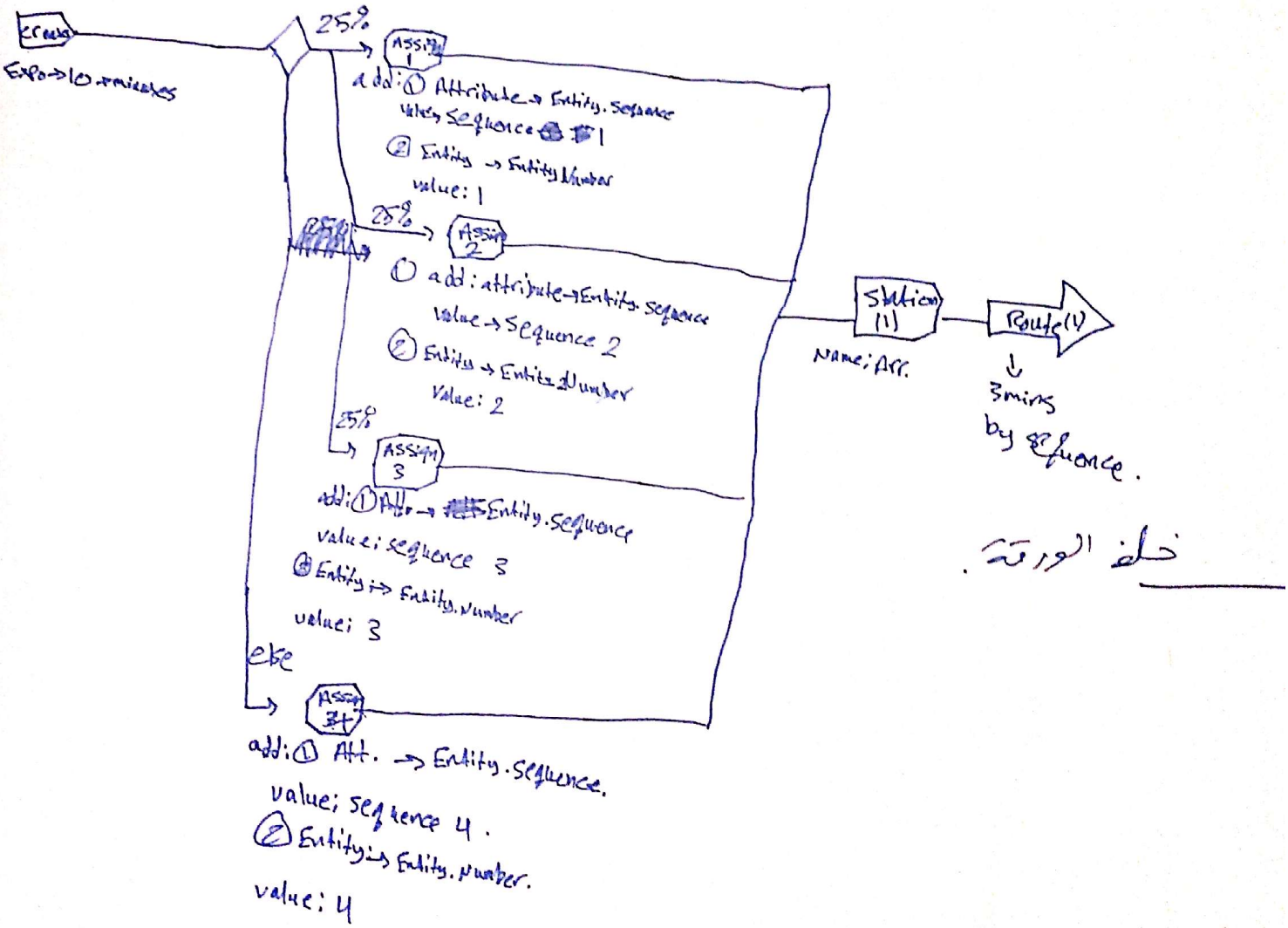
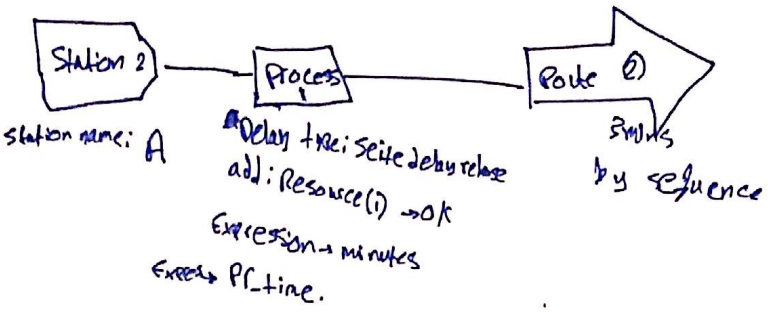
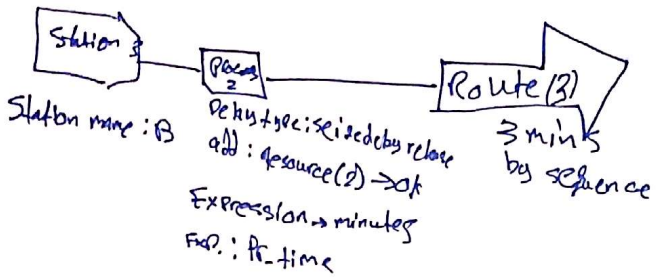
Q5) A part arrives every 10 minutes to a system having three workstations (A, B, and C), where each workstation has a single machine; the fi rst part arrives at time 0. There are four part types, each with equal probability of arriving. The process plans for the four part types are given here. The entries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

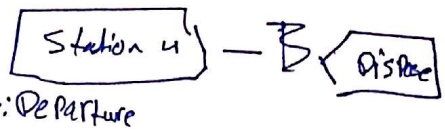
Part Type	Workstation/ Process Time	Workstation/ Process Time	Workstation/ Process Time
Part 1	A 5,5,9,5,13,5	C 8,5,14,1,19,7	
Part 2	A 8,9,13,5,18,1	B 9,15,21	C 4,3,8,5,12,7
Part 3	A 8,4,12,15,6	B 5,3,9,5,13,7	
Part 4	B 9,3,12,6,16,0	C 8,6,11,4,14,2	

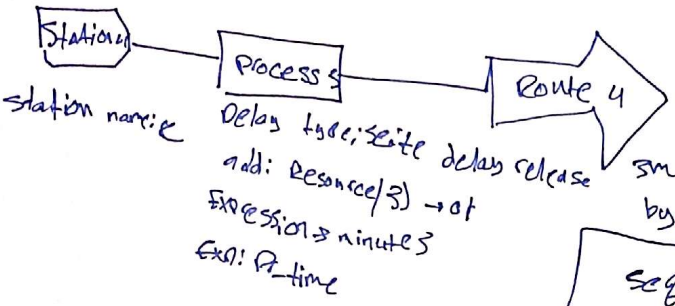
Assume that the transfer time between arrival and the first station, between all stations, and between the last station and the system exit is 3 minutes. Use the Sequence feature to direct the parts through the system and to assign the processing times at each station. Model using arena (7 points)











Data definition:

→ Sequences:

add 4 sequences:

sequence1:

→ rows →

Add 3 (rows)

Station	Attribute	Pr_time	tria(5.5, 9.5, 13.5)
→ A			
C	Attribute	Pr_time	tria(8.5, 14.7, 19.7)
Departure			

sequence (2):

Add 4 (rows):

Station	Att.	Pr_time	tria(9, 15, 21)
A			
B	Att.	=	=
C			
Departure	Att.	=	= (4.3, 8.5, 12.7)

Sequence 3:

Add 3 rows:

Station	Att.	Pr_time	tria(8.4, 12, 15.6)
A			
B	Att.	Pr_time	= (5.3, 9.5, 12.2)
Departure			

Sequence 4

Add 3 rows:

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