College of Science
Statistics and Operations Research Dep.

كلية العلوم
قسم الإحصاء وبحوث العمليات

3rd Assignment (Apr. 2020)
Year 1440-1441 H 2nd Semester

Course name & code	OPER 441 – Modeling and Simulation 441 بحث – النمذجة والمحاكاة	اسم ورمز المقرر
Instructor's Name	Dr. Khalid Alnowibet د. خالد النويبت	أستاذ المادة

Student's Name		اسم الطالب(ـه)
Student's Uni.ID.		الرقم الجامعي
Section No.		رقم الشعبة
Serial No.		الرقم التسلسلي

Instruction and guides for the assignment:

1. This assignment is designed to guide you to understand fully the topics and practice covered in the 1st month of the course.
2. To give you plenty of time to review and apply the materials for the answer, the assignment duration is from **2:00pm** Thursday April 16 until **Saturday Apr. 18 @ 11:00 before midnight**
3. You can use the lecture notes, the textbook, Excel for your answer.
4. You are the guardian of your behavior in this assignment. This assignment is totally for your independent effort. **Do not attempt** to collaboration or communication with anyone about the questions of the assignment, it is totally not allowed by any means.
5. Write all your answers on an Excel file. The file must contain both active work sheet and fixed worksheet. Put all the fixed answers in single worksheet and name it as (Fixed Ans.). Make sure to clearly indicate the number of the question answered.
6. Email you files to the address knowibet@ksu.edu.sa . Write the subject of the email as:

   OPER-441-Assignment#3 <<Section Number>> , << your name>> , <<your KSU ID >>
7. Make sure to make your document as **organized** as possible.

   وفقكم الله وييسر لكم .. وحفظكم ورعاكم

Application #1:

ABC Department store sells modern style clothing. The cost per unit of the new style clothing is random following the distribution:

Price (SR)	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Prob.	0.0168	0.0896	0.2090	0.2787	0.2322	0.1239	0.0413	0.0079	0.0007

Also, the selling price (per unit) is a random variable. The clothing style is seasonal. Meaning, if the style is sold during the season, then they will have a high value. If the clothing is sold out of season then the store must announce special offers to sell the leftovers. The special offer prices is considered random variable. Model this system using simulation under the following cases.

Case-I

- The demand on the clothing is a random variable that follows the shifted Bionomial distribution with shift $\delta = 100$ and parameters ($n = 50$, $p = 0.6$).
- Selling price during the season follows discrete integer value between 10 and 20 and shifted by the unit cost. For example, if ABC store buy the unit for 12 SR, then the selling price is shifted discrete uniform with shift δ=12.
- The leftover is sold at a fixed discount of 60% from the selling price. For example, if the selling price per unit is 25 SR during the season then the special offer price by the end of season is 10 SR.

ABC store wants to decide whether to order Q= 100 units, Q=150 units or Q= 200 units for the next season. Using simulation on Excel, find the best decision using the net profit function of the demand and the order quantity. Perform the following:

a. Using data table (fixed data) for 500 simulation runs, give the average of net profits, standard deviation, 95% confidence interval.
b. Make a histogram for the simulation output in the data table using excel

Case-II

- The demand on clothings is a random variable that follows the positive integer normal distribution with μ= 120 and σ= 20 (use abs(int(…)) function in excel)
- Selling price during the season follows shifted Bionomial distribution with shift δ = unit cost and parameters ($n = 10$, $p = 0.35$).
- The leftover is sold at a random discount follows discrete uniform DU[40%, 65%] from the selling price.

ABC store wants to decide whether to order Q= 80 units, Q=120 units or Q= 160 units for the next season. Using simulation on Excel, find the best decision using the net profit function of the demand and the order quantity. Perform the following:

a. Using data table (fixed data) for 500 simulation runs, give the average of net profits, standard deviation, 95% confidence interval.
b. Make a histogram for the simulation output in the data table using excel

Application #2:

Patients arrive to a dental clinic according to a random process. The patients are served as first come first served bases. If the patient arrive and find the dentist busy he waits for his turn. Assume that the waiting room is infinite. Simulate this application under the following cases.

Case-I

- All patients request the same service which takes a random amount of time (in minutes) that follows integer exponential with mean = 15 minutes and shift parameter δ= 5 minutes.(use integer function int(…))
- The time between arrivals is assumed to follow exponential with mean = 10 and shift parameter δ where $\delta \sim$ discrete uniform between 8 minutes and 15 minutes

a. Using simulation on Excel to evaluate the performance of the clinic by using data table (fixed data) for 100 simulation runs, each run has 100 arrivals and give the values of (i), (ii) and(iii), standard deviation and 95% confidence interval.
   i. The average waiting time for a patient if he wait.
   ii. The percentage that there is no patients in the clinic.
   iii. The average number of patients served per hour.

Patient #	Time between Patients	Arrival Time	Service Time	Starting service	Patient Wait??	Waiting Time	Dep Time	Clinic Idle Time
1								
2								
3								
4								
5								
6								
7								
8								
9								

b. Using your simulation output for 100 arrival, fixed the data and find the distribution of number of patients in the system N(t) for N = 0,1,2,3,4,5,6,7,8,9,10 only.

Case-II

- Patients request one of three same service which takes a random amount of time

Service Type	Percentage Patients	Service time
Service 1	45 % of the patients	Discrete uniform [10, 20]
Service 2	35 % of the patients	integer exponential with mean = 15 minutes and shift parameter δ= 5 (use int(..))
Service 3	20% 0f the patients	Integer Gamma dist. With α = 5 and β = 4

- The time between arrivals is assumed to follow exponential with mean = 10 and shift parameter δ where $\delta \sim$ discrete uniform between 8 minutes and 15 minutes

Using simulation on Excel to evaluate the performance of the clinic by using data table (fixed data) for 100 simulation runs, each run has 100 arrivals and give the values of (i), (ii) and(iii), standard deviation and 95% confidence interval.

i. The average waiting time for a patient if he wait.
ii. The percentage that there is no patients in the clinic.
iii. The average number of patients served per hour.

Patient #	Time between Patients	Arrival Time	Service Type	Service Time	Starting service	Patient Wait??	Waiting Time	Dep Time	Clinic Idle Time
1									
2									
3									
4									
5									
6									
7									
8									
9									

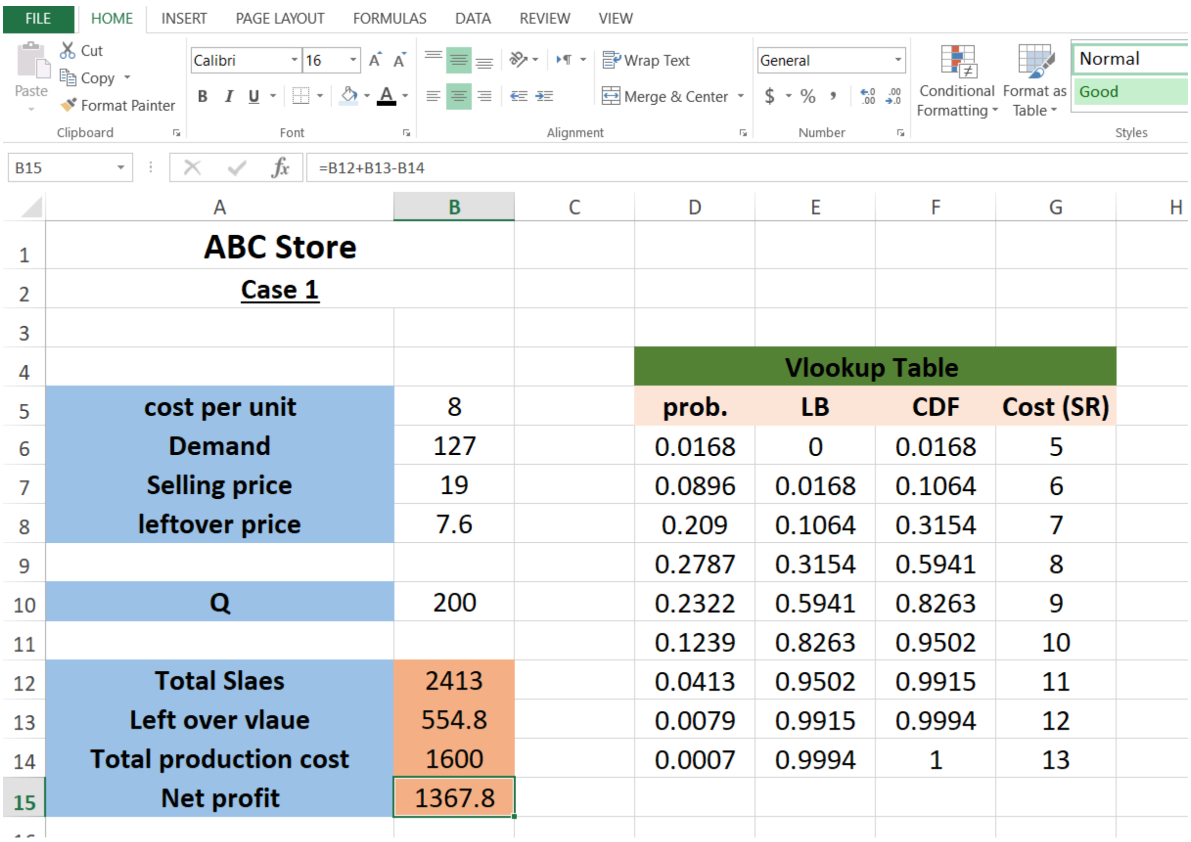
Application #1:

Unit cost

Price (SR)	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Prob.	0.0168	0.0896	0.2090	0.2787	0.2322	0.1239	0.0413	0.0079	0.0006

Case-I

- **Demand:** shifted Bionomial (n = 50, p = 0.6) with shift δ = 100
- **Selling Price:** Discrete Integer (10 and 20) and shifted by the δ = unit cost.
- **The Leftover Value:** discount of 60% from the selling price.



	A	B	C	D	E	F	G	H
1	ABC Store							
2	Case 1							
3								
4				Vlookup Table				
5	cost per unit	8		prob.	LB	CDF	Cost (SR)	
6	Demand	127		0.0168	0	0.0168	5	
7	Selling price	19		0.0896	0.0168	0.1064	6	
8	leftover price	7.6		0.209	0.1064	0.3154	7	
9				0.2787	0.3154	0.5941	8	
10	Q	200		0.2322	0.5941	0.8263	9	
11				0.1239	0.8263	0.9502	10	
12	Total Slaes	2413		0.0413	0.9502	0.9915	11	
13	Left over vlaue	554.8		0.0079	0.9915	0.9994	12	
14	Total production cost	1600		0.0007	0.9994	1	13	
15	Net profit	1367.8						

	A	B	C	D	E	F	G
1	ABC Store						
2	Case 1						
3							
4				Vlookup Table			
5	cost per unit	=VLOOKUP(RAND(),$E$6:$G$14,3)		prob.	LB	CDF	Cost (SR)
6	Demand	=BINOM.INV(50,0.6,RAND())+100		0.0168	0	=D6	5
7	Selling price	=RANDBETWEEN(10,20)+$B$5		0.0896	0.0168	=F6+D7	6
8	leftover price	=0.4*$B$7		0.209	0.1064	=F7+D8	7
9				0.2787	0.3154	=F8+D9	8
10	Q	200		0.2322	0.5941	=F9+D10	9
11				0.1239	0.8263	=F10+D11	10
12	Total Slaes	=B7*MIN(B6,B10)		0.0413	0.9502	=F11+D12	11
13	Left over vlaue	=B8*MAX(0,B10-B6)		0.0079	0.9915	=F12+D13	12
14	Total production cost	=B5*B10		0.0007	0.9994	=F13+D14	13
15	Net profit	=B12+B13-B14					
16							
17							

	I	J	K	L	M	N	O	P	Q	R
4	data table									
5	Day	Total Slaes	Left over vlaue	Total production cost	Net profit					
6		2413	554.8	1600	1367.8		Average	2065.1		
7	1	3484	686.4	1800	2370.4		STDV	501.968		
8	2	2413	554.8	1600	1367.8		LB-95%	2020.99		
9	3	3672	691.2	1800	2563.2		UB-95%	2109.2		
10	4	3432	707.2	1800	2339.2					
11	5	3696	761.6	1600	2857.6					
12	6	2430	468	1600	1298					
13	7	2814	554.4	1400	1968.4		Q	100	150	200
14	8	2620	552	1600	1572		Average	1505.4	1947.73	2058.1
15	9	2926	589.6	1600	1915.6		STDV	315.769	442.457	487.954
16	10	2394	562.4	1200	1756.4		LB-95%	1477.65	1908.85	2015.22
17	11	2772	571.2	1400	1943.2		UB-95%	1533.15	1986.6	2100.97
18	12	2646	621.6	1600	1667.6					
19	13	2580	568	1800	1348					
20	14	3458	696.8	1400	2754.8		I will choose Q=200 to be the optimal			
21	15	3537	745.2	1400	2882.2					

Order quantities: Q= 100 units, Q=150 units or Q= 200. Perform the following:

a. Data Table for 500 simulation runs: give the average of net profits, standard deviation, 95% confidence interval.

b. Make a histogram for G(Q,D) of the best Q only

Q	100	150	200
Average	1505.4	1947.73	2058.1
STDV	315.769	442.457	487.954
LB-95%	1477.65	1908.85	2015.22
UB-95%	1533.15	1986.6	2100.97

Q	100	150	200

averge	1493.4	1961.208	2011.777
STDEV	317.5817	452.9802	485.1641
LB-95%	1465.496	1921.407	1969.148
UB-95%	1521.304	2001.009	2054.406

Case-II

- **Demand:** positive integer normal distribution with μ= 120 and σ= 20 (use abs(int(…)) function in excel)

- **Selling Price:** Bionomial (n = 10, p = 0.35) with shift δ = unit cost.

- **The Leftover Value:** discount DU[40%, 65%] from the selling price

Q	80	120	160
Average	276.601	379.302	320.221
STDV	116.885	191.297	259.569
LB-95%	266.33	362.493	297.414
UB-95%	286.871	396.11	343.028

	q=80	q=120	q=160
Average of net profit	261.23	355.38	306.34
standard diviation	122.97	193.70	243.22
LB- 95%	250.43	338.36	284.97
UB- 95%	272.04	372.40	327.71

Get External Data | Connections | Sort & Filter | Data Tools

H19

	A	B	C	D	E	F	G	H
1	ABC Store							
2	Case 2							
3								
4				Vlookup Table				
5	cost per unit	7		prob.	LB	CDF	Cost (SR)	
6	Demand	83		0.0168	0	0.0168	5	
7	Selling price	8		0.0896	0.0168	0.1064	6	
8	leftover price	3.36		0.209	0.1064	0.3154	7	
9				0.2787	0.3154	0.5941	8	
10	Q	120		0.2322	0.5941	0.8263	9	
11				0.1239	0.8263	0.9502	10	
12	Total Slaes	664		0.0413	0.9502	0.9915	11	
13	Left over vlaue	124.32		0.0079	0.9915	0.9994	12	
14	Total production cost	840		0.0007	0.9994	1	13	
15	Net profit	-51.68						
16								
17								

Get External Data | Connections | Sort & Filter | Data Tools | Outline | Analysis

D4 | fx | Vlookup Table

	A	B	C	D	E	F	G
1		ABC Store					
2		Case 2					
3							
4				Vlookup Table			
5	cost per unit	=VLOOKUP(RAND(),$E$6:$G$14,3)		prob.	LB	CDF	Cost (SR)
6	Demand	=ABS(INT(NORM.INV(RAND(),120,20)))		0.0168	0	=D6	5
7	Selling price	=BINOM.INV(10,0.35,RAND())+B5		0.0896	0.0168	=F6+D7	6
8	leftover price	=(1-(RANDBETWEEN(40,65)/100))*B7		0.209	0.1064	=F7+D8	7
9				0.2787	0.3154	=F8+D9	8
10	Q	120		0.2322	0.5941	=F9+D10	9
11				0.1239	0.8263	=F10+D11	10
12	Total Slaes	=B7*MIN(B6,B10)		0.0413	0.9502	=F11+D12	11
13	Left over vlaue	=B8*MAX(0,B10-B6)		0.0079	0.9915	=F12+D13	12
14	Total production cost	=B5*B10		0.0007	0.9994	=F13+D14	13
15	Net profit	=B12+B13-B14					
16							
17							

<u>Order quantities:</u> <u>Q= 80 units, Q=120 units or Q= 160</u>. Perform the following:

a. Data Table for 500 simulation runs: give the <u>average of net profits</u>, standard deviation, 95% confidence interval.

b. Make a histogram for G(Q,D) of the best Q only

<u>Application #2:</u>

Patients arrive to a dental clinic according to a random process. The patients are served as first come first served bases. If the patient arrive and find the dentist busy he waits for his turn. Assume that the waiting room is infinite. Simulate this application under the following cases.

G5 | fx | Patient Wait??

	A	B	C	D	E	F	G	H	I	J
1		Dental clinic								
2		Case 1 (a&b)								
3										
4										
5		Patient #	Time Between Patients	Arrival Time	Service Time	Service Start Time	Patient Wait??	Waiting Time	Dep Time	Clinic Idle Time
6		1	11.399	11.399	12	11.399	0	0	23.399	11.399
7		2	27.443	38.842	23	38.842	0	0.0000	61.842	15.443
8		3	19.728	58.570	11	61.842	1	3.2720	72.842	0.000
9		4	19.655	78.225	17	78.225	0	0.0000	95.225	5.383
10		5	13.537	91.762	13	95.225	1	3.4629	108.225	0.000
11		6	14.002	105.765	18	108.225	1	2.4605	126.225	0.000
12		7	13.708	119.473	14	126.225	1	6.7520	140.225	0.000
13		8	13.828	133.301	10	140.225	1	6.9238	150.225	0.000
14		9	15.175	148.476	38	150.225	1	1.7488	188.225	0.000
15		10	23.838	172.314	15	188.225	1	15.9108	203.225	0.000
16		11	13.569	185.884	18	203.225	1	17.3415	221.225	0.000
17		12	23.839	209.723	9	221.225	1	11.5024	230.225	0.000
18		13	14.768	224.491	9	230.225	1	5.7341	239.225	0.000
19		14	22.426	246.917	10	246.917	0	0.0000	256.917	7.692
20		15	11.109	258.026	32	258.026	0	0.0000	290.026	1.109
21		16	15.122	273.148	14	290.026	1	16.8785	304.026	0.000
22		17	27.222	300.370	15	304.026	1	3.6561	319.026	0.000
23		18	8.933	309.303	25	319.026	1	9.7235	344.026	0.000
24		19	17.862	327.165	8	344.026	1	16.8614	352.026	0.000
25		20	22.632	349.797	37	352.026	1	2.2296	389.026	0.000

	Patient #	Time Between Patients	Arrival Time	Service Time	Service Start Time	Patient Wait??	Waiting Time	Dep Time	Clinic Idle Time
Dental clinic									
Case 1 (a&b)									
	1	=-10*LN(1-RAND())+RANDBETWEEN(8,15)	=C6	=INT(-15*LN(1-RAND()))+5	=D6	0	0	=D6+E6+H6	=D6
	2	=-10*LN(1-RAND())+RANDBETWEEN(8,15)	=C7+D6	=INT(-15*LN(1-RAND()))+5	=IF(I6<=D7,D7,I6)	=IF(D7>I6,0,1)	=IF(G7,I6-D7,0)	=D7+E7+H7	=IF(D7>I6,D7-I6,0)
	3	=-10*LN(1-RAND())+RANDBETWEEN(8,15)	=C8+D7	=INT(-15*LN(1-RAND()))+5	=IF(I7<=D8,D8,I7)	=IF(D8>I7,0,1)	=IF(G8,I7-D8,0)	=D8+E8+H8	=IF(D8>I7,D8-I7,0)
	4	=-10*LN(1-RAND())+RANDBETWEEN(8,15)	=C9+D8	=INT(-15*LN(1-RAND()))+5	=IF(I8<=D9,D9,I8)	=IF(D9>I8,0,1)	=IF(G9,I8-D9,0)	=D9+E9+H9	=IF(D9>I8,D9-I8,0)
	5	=-10*LN(1-RAND())+RANDBETWEEN(8,15)	=C10+D9	=INT(-15*LN(1-RAND()))+5	=IF(I9<=D10,D10,I9)	=IF(D10>I9,0,1)	=IF(G10,I9-D10,0)	=D10+E10+H10	=IF(D10>I9,D10-I9,0)
	6	=-10*LN(1-RAND())+RANDBETWEEN(8,15)	=C11+D10	=INT(-15*LN(1-RAND()))+5	=IF(I10<=D11,D11,I10)	=IF(D11>I10,0,1)	=IF(G11,I10-D11,0)	=D11+E11+H11	=IF(D11>I10,D11-I10,0)
	7	=-10*LN(1-RAND())+RANDBETWEEN(8,15)	=C12+D11	=INT(-15*LN(1-RAND()))+5	=IF(I11<=D12,D12,I11)	=IF(D12>I11,0,1)	=IF(G12,I11-D12,0)	=D12+E12+H12	=IF(D12>I11,D12-I11,0)
	8	=-10*LN(1-RAND())+RANDBETWEEN(8,15)	=C13+D12	=INT(-15*LN(1-RAND()))+5	=IF(I12<=D13,D13,I12)	=IF(D13>I12,0,1)	=IF(G13,I12-D13,0)	=D13+E13+H13	=IF(D13>I12,D13-I12,0)
	9	=-10*LN(1-RAND())+RANDBETWEEN(8,15)	=C14+D13	=INT(-15*LN(1-RAND()))+5	=IF(I13<=D14,D14,I13)	=IF(D14>I13,0,1)	=IF(G14,I13-D14,0)	=D14+E14+H14	=IF(D14>I13,D14-I13,0)
	10	=-10*LN(1-RAND())+RANDBETWEEN(8,15)	=C15+D14	=INT(-15*LN(1-RAND()))+5	=IF(I14<=D15,D15,I14)	=IF(D15>I14,0,1)	=IF(G15,I14-D15,0)	=D15+E15+H15	=IF(D15>I14,D15-I14,0)

Case-I

- **Service time:** time (in minutes) that follows integer exponential with mean = 15 minutes and shift parameter δ= 5 minutes.(use integer function int(…))
- **Arrival Process:** The time between arrivals is exponential with mean = 10 and shift parameter δ where δ ~ DU[8,15] minutes

a. **Data Table** for 100 simulation runs, each run has 100 arrivals:
Give the Average of (i), (ii) and(iii), standard deviation and 95% confidence interval.
   i. The average waiting time for a patient if he wait.
   ii. The percentage that there is no patients in the clinic.
   iii. The average number of patients served per hour.

a)

Average waiting time	=SUM(H6:H105)/SUM(G6:G105)
prob. no patient in clinic	=SUM(J6:J105)/I105
Average # patients served per hour	=(100/F105)*60

	Avg WT	prob. no patient	avg # patients served/h
Average	=AVERAGE(R8:R107)	=AVERAGE(S8:S107)	=AVERAGE(T8:T107)
STDV	=STDEV.S(R8:R107)	=STDEV.S(S8:S107)	=STDEV.S(T8:T107)
LB-95%	=M13-CONFIDENCE.T(0.05	=N13-CONFIDENCE.T(0.05,N14,100)	=O13-CONFIDENCE.T(0.05,O14,100)
UB-95%	=M13+CONFIDENCE.T(0.0	=N13+CONFIDENCE.T(0.05,N14,100)	=O13+CONFIDENCE.T(0.05,O14,100)

	Avg WT	prob. no patient	avg # patients served/h
Average	55.737	0.1276	2.7246
STDV	33.214	0.0640	0.1454
LB-95%	49.147	0.1149	2.6958
UB-95%	62.327	0.1403	2.7535

	Avg WT	prob. no patient	avg # patients served/h
Average	55.259	0.1273	2.7295
STDV	33.579	0.0618	0.1178
LB-95%	48.596	0.1151	2.7062
UB-95%	61.922	0.1396	2.7529

	Avg WT	prob. no patient	avg # patients served/h
Average	58.009	0.1222	2.7124
STDV	32.981	0.0611	0.1192
LB-95%	51.465	0.1101	2.6887
UB-95%	64.553	0.1343	2.7361

b. The distribution of number of patients in the system N(t) for N = 0,1,2,3,4,5,6,7,8,9,10 only.

N(t)	P(N(t))
0	0.1821
1	0.2820
2	0.1822
3	0.1255
4	0.1063
5	0.0639
6	0.0448
7	0.0128
8	0
9	0
10	0

N(t)	P(N(t))
0	0.06
1	0.14
2	0.09
3	0.05
4	0.12
5	0.27
6	0.13
7	0.09
8	0.04
9	0.00
10	0.00
sum	**1.00**

Case-II

- **Service Time:**

Service Type	Percentage Patients	Service time
Service 1	45 % of the patients	Discrete uniform [10, 20]
Service 2	35 % of the patients	integer exponential with mean = 15 minutes and shift parameter δ= 5 (use int(..))
Service 3	20% 0f the patients	Integer Gamma dist. With α = 5 and β = 4

- **<u>Arrival Process:</u>** The time between arrivals is exponential with mean = 10 and shift parameter δ where $\delta \sim DU[8,15]$ minutes

I12 =H12+I11

Dental clinic

<u>Case 2</u>

vlookup table			
pb.	LB	CDF	service
0.45	0	0.45	1
0.35	0.45	0.8	2
0.2	0.8	1	3

Patient #	Time Between Patients	Arrival Time	service type	Service Time	Service Start Time	Patient Wait??	Waiting Time	Dep Time	Clinic Idle Time
1	11.667	11.7	1	18	11.667	0	0.0	29.7	11.7
2	22.597	34.3	1	11	34.264	0	0.0	45.3	4.6
3	14.399	48.7	2	21	48.663	0	0.0	69.7	3.4
4	19.089	67.8	2	7	69.663	1	1.9	76.7	0.0
5	17.643	85.4	2	25	85.394	0	0.0	110.4	8.7
6	22.578	108.0	2	28	110.394	1	2.4	138.4	0.0
7	21.962	129.9	2	9	138.394	1	8.5	147.4	0.0
8	17.364	147.3	1	16	147.394	1	0.1	163.4	0.0
9	20.761	168.1	1	17	168.060	0	0.0	185.1	4.7
10	17.577	185.6	2	15	185.637	0	0.0	200.6	0.6
11	25.213	210.9	1	18	210.850	0	0.0	228.9	10.2
12	16.625	227.5	1	14	228.850	1	1.4	242.9	0.0
13	14.741	242.2	1	11	242.850	1	0.6	253.9	0.0
14	15.753	258.0	1	12	257.969	0	0.0	270.0	4.1
15	23.700	281.7	2	47	281.669	0	0.0	328.7	11.7
16	26.432	308.1	1	20	328.669	1	20.6	348.7	0.0
17	18.581	326.7	2	12	348.669	1	22.0	360.7	0.0
18	15.693	342.4	1	15	360.669	1	18.3	375.7	0.0
19	17.482	359.9	1	18	375.669	1	15.8	393.7	0.0
20	19.942	379.8	2	62	393.669	1	13.9	455.7	0.0
21	14.198	394.0	3	31	455.669	1	61.7	486.7	0.0

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J7 =VLOOKUP(RAND(),$C$9:$E$11,3)

Patient #	Time Between Patients	Arrival Time	service type	
1	=-10*LN(1-RAND())+RANDBETWEEN(8,15)	=H5	=VLOOKUP(RAND(),$C$9:$E$11,3)	=IF(J5=1,10+INT((20-10
2	=-10*LN(1-RAND())+RANDBETWEEN(8,15)	=H6+I5	=VLOOKUP(RAND(),$C$9:$E$11,3)	=IF(J6=1,10+INT((20-10
3	=-10*LN(1-RAND())+RANDBETWEEN(8,15)	=H7+I6	=VLOOKUP(RAND(),$C$9:$E$11,3)	=IF(J7=1,10+INT((20-10
4	=-10*LN(1-RAND())+RANDBETWEEN(8,15)	=H8+I7	=VLOOKUP(RAND(),$C$9:$E$11,3)	=IF(J8=1,10+INT((20-10
5	=-10*LN(1-RAND())+RANDBETWEEN(8,15)	=H9+I8	=VLOOKUP(RAND(),$C$9:$E$11,3)	=IF(J9=1,10+INT((20-10
6	=-10*LN(1-RAND())+RANDBETWEEN(8,15)	=H10+I9	=VLOOKUP(RAND(),$C$9:$E$11,3)	=IF(J10=1,10+INT((20-1

J	K
ervice type	Service Time
AND(),$C$9:$E$11,3)	=IF(J5=1,10+INT((20-10+1)*RAND()),IF(J5=2,INT(-15*LN(1-RAND()))+5,INT(GAMMA.INV(RAND(),5,4))))
AND(),$C$9:$E$11,3)	=IF(J6=1,10+INT((20-10+1)*RAND()),IF(J6=2,INT(-15*LN(1-RAND()))+5,INT(GAMMA.INV(RAND(),5,4))))
AND(),$C$9:$E$11,3)	=IF(J7=1,10+INT((20-10+1)*RAND()),IF(J7=2,INT(-15*LN(1-RAND()))+5,INT(GAMMA.INV(RAND(),5,4))))
AND(),$C$9:$E$11,3)	=IF(J8=1,10+INT((20-10+1)*RAND()),IF(J8=2,INT(-15*LN(1-RAND()))+5,INT(GAMMA.INV(RAND(),5,4))))
AND(),$C$9:$E$11,3)	=IF(J9=1,10+INT((20-10+1)*RAND()),IF(J9=2,INT(-15*LN(1-RAND()))+5,INT(GAMMA.INV(RAND(),5,4))))
AND(),$C$9:$E$11,3)	=IF(J10=1,10+INT((20-10+1)*RAND()),IF(J10=2,INT(-15*LN(1-RAND()))+5,INT(GAMMA.INV(RAND(),5,4))))
[illegible]	[illegible]

J7 =VLOOKUP(RAND(),$C$9:$E$11,3)

	L	M	N	O	P
4	Service Start Time	Patient Wait??	Waiting Time	Dep Time	Clinic Idle Time
5	=I5	0	0	=I5+K5+N5	=I5
6	=IF(O5<=I6,I6,O5)	=IF(I6>O5,0,1)	=IF(M6,O5-I6,0)	=I6+K6+N6	=IF(I6>O5,I6-O5,0)
7	=IF(O6<=I7,I7,O6)	=IF(I7>O6,0,1)	=IF(M7,O6-I7,0)	=I7+K7+N7	=IF(I7>O6,I7-O6,0)
8	=IF(O7<=I8,I8,O7)	=IF(I8>O7,0,1)	=IF(M8,O7-I8,0)	=I8+K8+N8	=IF(I8>O7,I8-O7,0)
9	=IF(O8<=I9,I9,O8)	=IF(I9>O8,0,1)	=IF(M9,O8-I9,0)	=I9+K9+N9	=IF(I9>O8,I9-O8,0)
10	=IF(O9<=I10,I10,O9)	=IF(I10>O9,0,1)	=IF(M10,O9-I10,0)	=I10+K10+N10	=IF(I10>O9,I10-O9,0)

Data Table for 100 simulation runs, each run has 100 arrivals:

Give the Average of (i), (ii) and(iii), standard deviation and 95% confidence interval.

i. The average waiting time for a patient if he wait.
ii. The percentage that there is no patients in the clinic.
iii. The average number of patients served per hour.

Average waiting time	=SUM(N5:N104)/SUM(M5:M104)
prob. no patient in clinic	=SUM(P5:P104)/O104
Average # patients served per hour	=(100/L104)*60

	Avg WT	prob. no patient	avg # patients served/h
Average	=AVERAGE(X7:X10(	=AVERAGE(Y7:Y106)	=AVERAGE(Z7:Z106)
STDV	=STDEV.S(X7:X106)	=STDEV.S(Y7:Y106)	=STDEV.S(Z7:Z106)
LB-95%	=S11-CONFIDENCE	=T11-CONFIDENCE.T(0.05,T12,100)	=U11-CONFIDENCE.T(0.05,U12,100)
UB-95%	=S11+CONFIDENCE	=T11+CONFIDENCE.T(0.05,T12,100)	=U11+CONFIDENCE.T(0.05,U12,100)

	Avg WT	prob. no patient	avg # patients served/h
Average	24.774	0.197	2.776
STDV	14.810	0.056	0.125
LB-95%	21.835	0.186	2.751
UB-95%	27.713	0.208	2.801

	Avg WT	prob. no patient	avg # patients served/h
Average	24.683	0.197	2.758
STDV	13.250	0.047	0.127
LB-95%	22.054	0.188	2.733
UB-95%	27.312	0.207	2.783

	Avg WT	prob. no patient	avg # patients served/h
Average	24.958	0.206	2.754
STDV	14.846	0.060	0.139
LB-95%	22.012	0.194	2.726
UB-95%	27.903	0.218	2.782