(2) ii) Compute Arrival time from IAT

.C.No	Random Digit	IAT	Arrival Time
1	–	–	0
2	913	8	8
3	727	6	14
4	015	1	15
5	948	8	23
6	309	3	26
7	922	8	34
8	753	7	41
9	235	2	43
10	302	3	46

iii) Determine Service Time Distribution Table

S.No	P(1/6)	Cumulative probability	Random Digit Assess
1	0.16	0.16	01-16
2	0.16	0.32	17-32
3	0.16	0.48	33-48
4	0.16	0.64	49-64
5	0.16	0.80	65-80
6	0.16	0.96	81-96

iv) Compute Service Time

S.No	Random digit	Service Time
1	84	6
2	10	1
3	74	5
4	53	4
5	17	2
6	79	5
7	91	6
8	67	5
9	89	6
10	38	3

v] Simulation Table for 10 customers

C.No	Arrival Time	Service Time	Time Service Begin	Time Service End	TSE − AT: Customer Time spent in System	TSB(n) − TSE(n−1): Idle Server Time	TSB − AT: Customer Time wait in queue
1	0	6	0	6	6 (6-0)	0	0
2	8	1	8	9	1 (9-8)	2(8-6)	0 (8-8)
3	14	5	14	19	5(19-14)	5(14-9)	0 (14-14
4	15	4	19	23	8	0	4 (19-15)
5	23	2	23	25	2	0	0
6	26	5	26	31	5	1	0
7	34	6	34	40	6	3	0
8	41	5	41	46	5	1	0
9	43	6	46	52	9	0	3
10	46	3	52	55	9	0	6

$$\text{Average waiting Time} = \frac{\text{Total time customer waiting in queue}}{\text{Total no. of customers}} = \frac{4+3+6}{10} = \frac{13}{10} = 1.3 \text{ min}$$

$$\text{Probability wait} = \frac{\text{No. of customers to wait}}{\text{Total no. of customers}} = \frac{3}{10} = 0.3 \text{ min}$$

$$\text{Probability of idle server} = \frac{\text{Total idle time of server}}{\text{Total run time of simulat}^n \text{ (TSE last value)}} = \frac{2+5+1+3+1}{55} = \frac{12}{55} = 0.218 \text{ min}$$

(3) Average Service Time = $\frac{\text{Total Service Time}}{\text{Total no. of customers}}$

$= \frac{6+1+5+4+2+5+6+5+6+3}{10} = \frac{43}{10} = 4.3\text{m}$

Average Time b/w arrival = $\frac{\text{Sum of all time b/w arrival}}{\text{No. of arrival} - 1}$

$= \frac{46}{10-1} = \frac{46}{9} = 5.11 \text{ min}$

Average waiting time those who wait in queue = $\frac{\text{Total time customer wait in queue}}{\text{Total no. of customer who wait}}$

$= \frac{4+3+6}{3} = \frac{13}{3} = 4.3 \text{ min}$

Average time customer spent in system = $\frac{\text{Total time customer spends in s/r}}{\text{Total no. of customers}}$

$= \frac{6+1+5+8+2+5+6+5+9+9}{10}$

$= \frac{56}{10} = 5.6 \text{ min}$

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2. A small grocery store has only one check out counte at random from 1-6 min apart. Each possible value of IAT has the same probability of occurance. The service time vary from 1 to 6 mins with probability shown below.

ST :	1	2	3	4	5	6
P :	0.10	0.20	0.25	0.30	0.10	0.05

Develop a simulation Table for 10 customers. Take a random digit for arrival :

13 27 15 48 9 22 53 35 2

Random digit for Service Time

84 10 74 53 17 91 79 67 38 89 sequentially.

Calc. Avg Service Time, probability of idle Service time, average b|w arrivals & avg. time customer spent in System.

i) Determine IAT Distribution Table

C.No	Probability (1/6)	Cumulative probability	Random digit assessment
1	0.16	0.16	01-16
2	0.16	0.32	17-32
3	0.16	0.48	33-48
4	0.16	0.64	49-64
5	0.16	0.80	65-80
6	0.16	0.96	81-96

ii) Compute Arrival time from IAT

C.No	RD	IAT	AT
1	-	-	0
2	13	1	1
3	27	2	3
4	15	1	4
5	48	3	7
6	9	1	8
7	22	2	10
8	53	4	14
9	35	3	17
10	2	1	18

iii) Determine ST Dist. Table

S.No	Probability	CP	RDA
1	0.10	0.10	01-10
2	0.20	0.30	11-30
3	0.25	0.55	31-55
4	0.30	0.85	56-85
		0.95	86-95

iv) Compute Service Time from Distribution Table

S.No	RD	ST
1	84	4
2	10	1
3	74	4
4	53	3
5	17	2
6	91	5
7	79	4
8	67	4
9	38	3
10	89	5

imulation Table for 10 customers

o	Arrival Time	Service Time	Time Service Begin	Time Service End	Cust. time spent in s/m	Idle Server Time	Cust. time wait in queue
	0	4	0	4	4	0	0
	1	1	4	5	4	0	3
	3	4	5	9	6	0	2
	4	3	9	12	8	0	5
	7	2	12	14	7	0	5
	8	5	14	19	11	0	6
	10	4	19	23	13	0	9
	14	4	23	27	13	0	9
	17	3	27	30	13	0	10
	18	5	30	35	17	0	12

erage Service Time = $\frac{35}{10}$ = 3.5 min

bability of Idle Server Time = $\frac{0}{35}$ = 0

rage Time b/w arrivals = $\frac{18}{9}$ = 2 min

erage time Customer spent in system = $\frac{61}{10}$ = 6.1 min

3. Consider a store with one checkout counter. Prepare simulation table & find out average waiting time of customer in q waiting queue, probability of idle server, average service time

IAT : 3 2 6 4 4 5 8 7

ST : 4 5 5 8 4 6 2 3 4

Assume 1st customer arrives at t=0.

i) Inter arrival distribution Table

C.No	IAT	AT
1	-	0
2	3	3
3	2	5
4	6	11
5	4	15
6	4	19
7	5	24
8	8	32
9	7	39

ii) Simulation table for 9 customers

C.No	AT	ST	TSB	TSE	Cust. spent in S/m.	Idle time of server	Cust. time wait in que
1	0	4	0	4	4	0	0
2	3	5	4	9	6	0	1
3	5	5	9	14	9	0	4
4	11	8	14	22	11	0	3
5	15	4	22	26	11	0	7
6	19	6	26	32	13	0	7
7	24	2	32	34	10	0	8
8	32	3	34	37	5	0	2
9	39	4	39	43	4	2	0

(5) Average waiting time of customer in waiting queue $= \frac{32}{7} = 4.57$ min

Probability of Idle Server $= \frac{2}{10} = 0.2$ min

Average Service Time $= \frac{41}{9} = 4.56$ min

Multichannel Problems :

Type I

4 Consider a simulation with a restaurant system where car & hope takes order & brings an item to the car. The car arrives in the manner :

Time b/w arrival :	1	2	3	4
Probability :	0.25	0.40	0.20	0.15

Consider 2 persons Able & Baker. Able is better & bit faster than Baker.

Able Service Time :

ST :	2	3	4	5
Prob :	0.30	0.28	0.25	0.17

Baker Service Time :

ST :	3	4	5	6
Prob :	0.35	0.25	0.20	0.20

Take a random digit for arrival :

26 98 90 26 42 74 80 68 22

Random digit for service time :

95 21 51 92 89 38 13 61 50 49

i) Determine Inter Arrival distribution Table

C.No	Probability	Cumulative Probability	Random Digit Assessment
1	0.25	0.25	01-25
2	0.40	0.65	26-65
3	0.20	0.85	66-85
4	0.15	1.00	86-00

ii) Compute AT from IAT distribution Table

C.No	RD	IAT	AT
1	-	-	0
2	26	2	2
3	98	4	6
4	90	4	10
5	26	2	12
6	42	2	14
7	74	3	17
8	80	3	20
9	68	3	23
10	22	1	24

iii) Able Service Time Distribution Table

S.No	Probability	CP	RDA
2	0.30	0.30	01-30
3	0.28	0.58	31-58
4	0.25	0.83	59-83
5	0.17	1.00	84-00

iv) Baker Service Time Distribution Table

S.No	Probability	CP	RDA
3	0.35	0.35	01-35
4	0.25	0.60	36-60
5	0.20	0.80	61-80
6	0.20	1.00	81-00

6) v) Simulation table for 10 customers

C.No	AT	RD for service	ST	When Able is Available	When Baker is Available	Server Choosen	Able		Baker		cust. in S/m	Idle Server time	wa in que
							TSB	TSE	TSB	TSE			
1	0	95	5	0	0	A	0	5	–	–	5	0	0
2	2	21	3	5	0	B	–	–	2	5	3	2	0
3	6	51	3	5	5	A	6	9	–	–	3	1	0
4	10	92	6	9	5	A	10	15	–	–	5	1	0
5	12	89	6	15	5	B	–	–	12	18	6	7	0
6	14	38	3	15	18	A	15	18	–	–	4	0	1
7	17	13	2	18	18	A	18	20	–	–	3	0	1
8	20	61	4	20	18	A	20	24	–	–	4	0	0
9	23	50	4	24	18	B	–	–	23	27	4	5	0
10	24	49	3	24	27	B	24	27	–	–	3	0	0

5) Consider Simulation table for Able & Baker problem where time b/w arrival are :

Time b/w arrival : 1 2 3 4 5

Probability : 0.20 0.15 0.05 0.20 0.40

Baker is faster than Able.

Service Time for Able :

ST : 3 4 5 6 2

Prob : 0.20 0.05 0.15 0.20 0.40

Service Time for Baker :

ST : 2 3 5 6 1

Prob : 0.15 0.20 0.05 0.20 0.40

Random Digit for Arrival :

98 90 42 80 22 26 74 26 68

Random Digit for Service Time :

49 50 61 13 38 89 92 51 21 95

i) Determine IAT distribution Table

C.No	Probability	CP	RDA
1	0.20	0.20	01-20
2	0.15	0.35	21-35
3	0.05	0.40	36-40
4	0.20	0.60	41-60
5	0.40	1.00	61-00

ii) Compute Arrival Time from IAT dist. table.

C.No	RD	IAT	AT
1	-	-	0
2	98	5	5
3	90	5	10
4	42	4	14
5	80	5	19
6	22	2	21
7	26	2	23
8	74	5	28
9	26	2	30
10	68	5	35

iii) Able Service Time Distribution Table

S.No	P	CP	RDA
3	0.20	0.20	01-20
4	0.05	0.25	21-25
5	0.15	0.40	26-40
6	0.20	0.60	41-60
2	0.40	1.00	61-00

iv) Baker Service Time Distribution Table

S.No	P	CP	RDA
2	0.15	0.15	01-15
3	0.20	0.35	16-35
5	0.05	0.40	36-40
6	0.20	0.60	41-60
1	0.40	1.00	61-00

(RD - Random Digit)

v) Simulation table for 10 customers

C.No	Arrival Time	RD of Servic	Servic Time	WhenAbl isAvailabl	whenBaker isAvailabl	Server Choosen	Abl		Baker		Cust time spent in s/m	Idl time of Server	Cust. t wait queu
							TSB	TSE	TSB	TSE			
1	0	49	6	0	0	B	-	-	0	6	6	0	0
2	5	50	6	0	6	A	5	11	-	-	6	5	0
3	10	61	1	11	6	B	-	-	10	11	1	4	0
4	14	13	2	11	11	B	-	-	14	16	2	3	0
5	19	38	5	11	16	B	-	-	19	24	5	3	0
6	21	89	2	11	24	A	21	23	-	-	2	10	0
7	23	92	2	23	24	A	23	25	-	-	2	0	0
8	28	51	6	25	24	B	-	-	28	34	6	4	0
9	30	21	4	25	34	B	30	34	-	-	4	5	0
10	35	95	1	34	34	A	-	-	35	36	1	1	0

Customer time Spent in s/m = TSE - AT

Idl time of Server = TSB(n) - TSE(n-1)

Customer time waiting in queue = TSB - AT

6. Consider Able Baker Dist. table, IAT having equal probability ratio 1 to 6 min apart.

* Able Service Time have equal probability ratio 1-5 min
Baker Service Time have equal probability ratio 1-4 min.
1-6

Random Digit for time b/w arrival :

62 89 9 62 24 47 8 86 22

Random Digit for Service Time :

59 12 15 29 28 83 13 16 5 94

Able is faster than Baker.

i) Determine IAT Distribution Table

C.No	P	CP	RDA
1	0.16	0.16	01-16
2	0.16	0.32	17-32
3	0.16	0.48	33-48
4	0.16	0.64	49-64
5	0.16	0.80	65-80
6	0.16	0.96	81-96

ii) Compute Arrival Time from IAT Dist. Table

C.No	RD	IAT	AT
1	-	-	0
2	62	4	4
3	89	6	10
4	9	1	11
5	62	4	15
6	24	2	17
7	47	3	20
8	8	1	21
9	86	6	27
10	22	2	29

- Distribution Table

S.No	P	CP	RDA
1	0.20	0.20	01-20
2	0.20	0.40	21-40
3	0.20	0.60	41-60
4	0.20	0.80	61-80
5	0.20	1.00	81-00

Distribution Table

S.No	P	CP	RDA
1	0.25	0.25	01-25
2	0.25	0.50	26-50
3	0.25	0.75	51-75
4	0.25	1.00	76-00

v) Simulation Table for 10 customers

C.No	AT	RD of service	ST	When Able is Available	When Baker is Available	Server Choosen	Able		Baker		Cust. spent in s/m	Idle time of servers	Cust. time wait in queue
							TSB	TSE	TSB	TSE			
1	0	59	3	0	0	A	0	3	-	-	3	0	0
2	4	12	1	3	0	A	4	5	-	-	1	1	0
3	10	15	1	5	0	A	10	11	-	-	1	5	0
4	11	29	2	11	0	A	11	13	-	-	2	0	0
5	15	98	15	13	0	A	15	20	-	-	2	2	0
6	17	83	4	20	0	B	-	-	17	21	2	17	0
7	20	13	1	20	21	A	20	21	-	-	1	0	0
8	21	16	1	21	21	A	21	22	-	-	1	0	0
9	27	5	1	22	21	A	27	28	-	-	2	5	0
10	29	94	5	28	21	A	29	34	-	-	5	1	0