

**Q1//** From an in-out survey conducted for a parking area consisting of 40 bays, the initial count was found to be 25. Table gives the result of the survey. The number of vehicles coming in and out of the parking lot for a time interval of 5 minutes is as shown in the table below. Find the accumulation, total parking load, average occupancy and efficiency of the parking lot.

**Table:** In-out survey data

Time	In	out
5	3	2
10	2	4
15	4	2
20	5	4
25	7	3
30	8	2
35	2	7
40	4	2
45	6	4
50	4	1
55	3	3
60	2	5

**Solution** The solution is shown in table below:

Time (1)	In (2)	Out (3)	Accumulation (4)	Occupancy (5)	Parking load (6)
5	3	2	26	65	130
10	2	4	24	60	120
15	4	2	26	65	130
20	5	4	27	67.5	135
25	7	3	31	77.5	155
30	8	2	37	92.5	185
35	2	7	32	80	160
40	4	2	34	85	170
45	6	4	36	90	180
50	4	1	39	97.5	195
55	3	3	39	97.5	195
60	2	5	36	90	180
Total					1735

- ✚ Accumulation can be found out as initial count plus number of vehicles that entered the parking lot till that time minus the number of vehicles that just exited for that particular time interval. For the first time interval of 5 minutes, accumulation can be found out as  $25+3-2 = 26$ . It is being tabulated in column 4.
- ✚ Occupancy or parking index is given by equation. For the first time interval of five minutes, **Parking index** =  $\frac{26}{40} \times 100 = 65\%$ . The occupancy for the remaining time slot is similarly calculated and is tabulated in column 5. Average occupancy is the average of the occupancy values for each time interval. Thus it is the average of all values given in column 5 and the value is 80.63%.
- ✚ Parking load is tabulated in column 6. It is obtained by multiplying accumulation with the time interval. For the first time interval, **parking load** =  $26 \times 5 = 130$  vehicle minutes.
- ✚ Total parking load is the summation of all the values in column 5 which is equal to **1935 vehicle minutes or 32.25 vehicle hours**

**Q2//** The parking survey data collected from a parking lot by license plate method is shown in the table below. Find the average occupancy, average turn-over, parking load, parking capacity and efficiency of the parking lot.

Table: License plate parking survey data

Bay	Time			
	0-15	15-30	30-45	45-60
1	1456	9813	-	5678
2	1945	1945	1945	1945
3	3473	5463	5463	5463
4	3741	3741	9758	4825
5	1884	1884	-	7594
6	-	7357	-	7893
7	-	4895	4895	4895
8	8932	8932	8932	-
9	7653	7653	8998	4821
10	7321	-	2789	2789
11	1213	1213	3212	4778
12	5678	6678	7778	8888

**Solution:**

Bay	Time				Time				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	15	30	45	60	15	30	45	60	Turn over
1	1456	9813	-	5678	1	1	0	1	3
2	1945	1945	1945	1945	1	1	1	1	1
3	3473	5463	5463	5463	1	1	1	1	2
4	3741	3741	9758	4825	1	1	1	1	3
5	1884	1884	-	7594	1	1	0	1	2
6	-	7357	-	7893	0	1	0	1	2
7	-	4895	4895	4895	0	1	1	1	1
8	8932	8932	8932	-	1	1	1	0	1
9	7653	7653	8998	4821	1	1	1	1	3
10	7321	-	2789	2789	1	0	1	1	2
11	1213	1213	3212	4778	1	1	1	1	3
12	5678	6678	7778	8888	1	1	1	1	4
	Accumulation				10	11	9	11	
	Occupancy				0.83	0.92	0.75	0.92	2.25

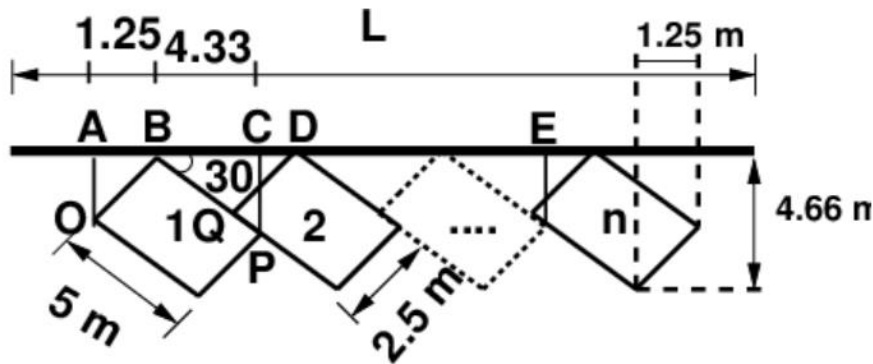
Columns 1 to 5 is the input data. The parking status in every bay is coded first. If a vehicle occupies that bay for that time interval, then it has a code 1. This is shown in columns 6, 7, 8 and 9 of the table corresponding to the time intervals 15, 30, 45 and 60 minutes.

- ✚ Turn-over is computed as the number of vehicles present in that bay for that particular hour. For the first bay, it is counted as 3. Similarly, for the second bay, one vehicle is present throughout that hour and hence turnout is 1 itself. This is being tabulated in column 10 of the table. Average turn-over  

$$= \frac{\text{Sum of turn-over}}{\text{Total number of bays}} = 2.25$$

- ✚ Accumulation for a time interval is the total of number of vehicles in the bays 1 to 12 for that time interval. Accumulation for first time interval of 15 minutes =  $1+1+1+1+1+0+0+1+1+1+1+1 = 10$
- ✚ Parking volume = Sum of the turn-over in all the bays = 27 vehicles.
- ✚ Average duration is the average time for which the parking lot was used by the vehicles. It can be calculated as sum of the accumulation for each time interval  $\times$  time interval divided by the parking volume =  $\frac{(10+11+9+11) \times 15}{27} = 22.78$  minutes/vehicle.
- ✚ Occupancy for that time interval is accumulation in that particular interval divided by total number of bays. For first time interval of 15 minutes, occupancy =  $(10 \times 100) / 12 = 83\%$  Average occupancy is found out as the average of total number of vehicles occupying the bay for each time interval. It is expressed in percentage. Average occupancy =  $\frac{0.83+0.92+0.75+0.92}{4} \times 100 = 85.42\%$ .
- ✚ Parking capacity = number of bays  $\times$  number of hours =  $12 \times 1 = 12$  vehicle hours
- ✚ Parking load = total number of vehicles accumulated at the end of each time interval  $\times$  time =  $\frac{(10+11+9+11) \times 15}{60} = 10.25$  vehicle hours.
- ✚ Efficiency =  $\frac{\text{Parking load}}{\text{Total number of bays}} = \frac{10.25}{12} = 85.42\%$ .

**Q3//** 30° parking: In thirty degree parking, the vehicles are parked at 30° with respect to the road alignment. In this case, more vehicles can be parked compared to parallel parking. Also there is better maneuverability. Delay caused to the traffic is also minimum in this type of parking. See figure below. **Determine the total length available for N vehicles parked.**



**Solution:**

$$AB = OB \sin 30^\circ = 1.25,$$

$$BC = OP \cos 30^\circ = 4.33,$$

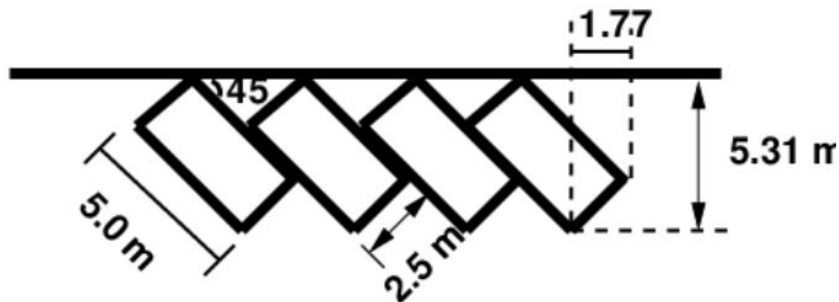
$$BD = DQ \cos 60^\circ = 5,$$

$$CD = BD - BC = 5 - 4.33 = 0.67,$$

$$AB + BC = 1.25 + 4.33 = 5.58$$

For  $N$  vehicles,  $L = AC + (N-1) CE = 5.58 + (N-1)5 = 0.58 + 5N$

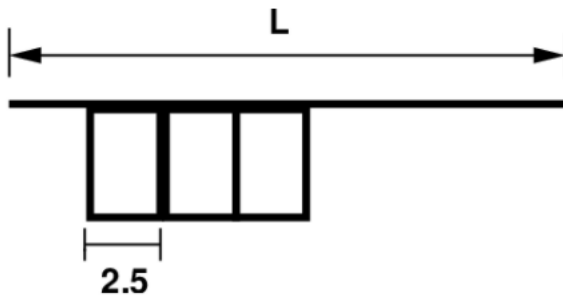
**Q4//** 45° parking: As the angle of parking increases, more number of vehicles can be parked. Hence compared to parallel parking and thirty degree parking, more number of vehicles can be accommodated in this type of parking. From figure below determine the length of parking space available for parking.



**Solution:**

$N$  number of vehicles in a given curb is  $L = 3.54 N + 1.77$

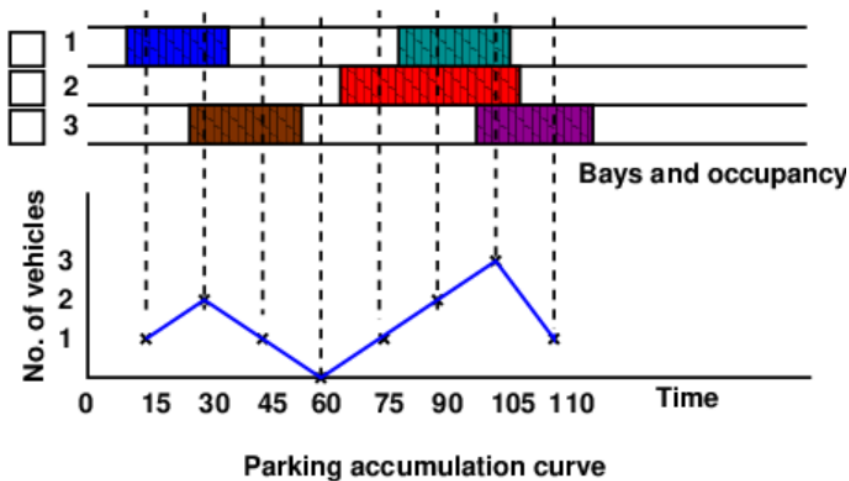
**Q5//** In right angle parking or 90° parking, the vehicles are parked perpendicular to the direction of the road. Although it consumes maximum width curb length required is very little. In this type of parking, the vehicles need complex maneuvering and this may cause severe accidents. This arrangement causes obstruction to the road traffic particularly if the road width is less. Determine the length of parking space available for parking.



**Solution:**

Length available for parking N number of vehicles is  $L = 2.5N$ .

**Q6//** To illustrate the various measures, consider a small example in figure 7, which shows the duration for which each of the bays are occupied (shaded portion). Now the accumulation graph can be plotted by simply noting the number of bays occupied at time interval of 15, 30, 45 etc. minutes is shown in the figure below.



**Determine the following:**

- ❖ Parking volume
- ❖ Parking load
- ❖ Average parking duration
- ❖ Parking turnover
- ❖ Parking Index

**Solution:**

Parking volume is given as 5 vehicles.

Parking load is given as  $(1 + 2 + 1 + 0 + 1 + 2 + 3 + 1) \frac{15}{60} = \frac{11 \times 15}{60} = 2.75$  veh hour.

Average parking duration is computed as  $\frac{2.75 \text{ veh hours}}{5 \text{ veh}} = 33$  minutes.

Parking turnover is obtained as  $\frac{5 \text{ veh/2 hours}}{3 \text{ bays}} = 0.83$  veh/hr/bay.

Parking index is calculated as  $\frac{2.75 \text{ veh hour}}{3 \times 2 \text{ veh hours}} \times 100 = 45.83\%$