Problem 1/ Determine level of service by segment and for the entire length for one direction of flow for through lane group for a 1.8-mi divided multilane class I urban street (FFS=50mi/h) with 4 signalized intersections. The spacing for each of the first and third intersections are 0.5 mi , while for the second and fourth intersections are 0.4 mi. The control delay is as follows:

Segment	1	2	3	4
Delay (sec)	11.0	10.6	6.0	5.6

Problem 2/ Develop a signal phase plan (design the timing plan with min. number of phases without cross conflict) for the intersection with layout and demand volumes shown in Figure below. The intersection is of two streets with one lane in each direction. The saturation flow rates are: 1750 pcphgpl for through, 1700 pcphgpl for right, 1650 pcphgpl for left, and 1670 pcphgpl for shared lanes. A 2 second all red interval is used

Problem 3/ At a particular section of roadway the spot speeds were observed with a mean value of 57 kph and a standard deviation of 4.5 kph, if the spot speed data is considered to be normally distributed, find:

1- The 70 percentile speed 2- Probability that the speed is < 50 kph 3- Probability that the speed is > 50 kph	4- Probability that the speed is between 40 and 70 kph 5- Probability that the speed lie between 30 kph and the mean

Problem 4/ The spot speeds at certain location on a highway are known to be normally distributed with a mean speed of 80 kph. Another method was used for observing the spot speed at the same location and a set of 90 observations was obtained. The mean speed was 81 kph and a standard deviation of 12 kph. Using statistical methods, is the second method

1- Differs from the first method?
2- Showing higher speeds than the first?

Problem 5/ Two lanes of a 3-lane one way carriageway is closed for repairs. The maximum mean free speed under conditions of low flow in the 3-lane position is 65 kph. Under conditions of low flow, observations show that the maximum mean free speed in the bottleneck is also 65 kph. The average space headway when vehicles are stationary is 12.5 m. The volume of traffic on the 3-lane road is 2700 vph. Assuming that the speed – concentration relation is linear, find:

1- The mean speed of traffic through the bottleneck caused by the closure of two lanes
2- The mean speed of traffic in the congested condition immediately on the approach to the bottleneck
3- The rate at which the queue of the congested traffic entering the bottleneck grows.

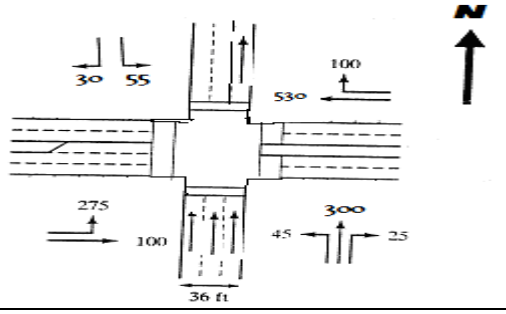
Problem 6/ A three phase isolated pretimed (fixed time) signalized intersection has the following necessary data :

Duration of analysis period = 1 hour Saturation flow rate = 1750 veh/h Total lost time per cycle = 15 seconds Effective green for lane group 1 (phase 1) = 20 seconds Effective	green for lane group 2 (phase 2) = 30 seconds Effective green for lane group 3 (phase 3) = 20 seconds Peak demand volume for lane group 1 = 350 veh/h Peak demand volume for lane group 2 = 450 veh/h Peak demand volume for lane group 3 = 400 veh/

Using HCM2000 method Find:

1- Cycle length
2- Capacity of each lane group
3- Degree of saturation (X) for each lane group
4- Average control delay per vehicle for each lane group
5- Average control delay per vehicle for the intersection

Problem 7/ Develop a signal phase plan (design the timing plan with min. number of phases without cross conflict) for the intersection with layout and demand volumes shown in Figure below. The intersection is of two streets as shown. The saturation flow rates are: 1750 pcphgpl for through, 1700 pcphgpl for right, 1650 pcphgpl for left, and 1670 pcphgpl for shared lanes and a 2 second all red interval is to be used.

PHF = 0.92 Target v/c = 0.9 Avg. speed = 30 mi/h Level grade	

Problem 8/ At a particular section of roadway the spot speeds were observed and tabulated as given in the following frequency table:

Speed (kph)	20 - 30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	100-110	110-120
frequency	4	6	36	60	71	84	65	45	22	5

If this data is assumed to be normally distributed, determine the:

1- Arithmetic mean speed(TMS)
2- Space mean speed (SMS)
3- Standard deviation
4- 50 percentile speed
5-Probability that the speed is > 70 kph
6-Probability that the speed is > the (mean + 5)
7-Probability that the speed lie between median and 30 kph

Problem 9/ On a certain road the speed - Flow relationship obtained was $Q = 150\ V_s - 1.2\ V_s^2$ Determine:

1-The free flow speed and the jam density 2-The capacity and the optimum speed.	1-The flow-density relationship 2- Using suitable scale draw the speed – flow curve and find the speed when the flow is 50 vph.

Problem 10/ One lane of a 3-lane one way carriageway is closed for repairs. The maximum mean free speed under conditions of low flow in the 3-lane position is 65 kph. Under conditions of low flow, observations show that the maximum mean free speed in the bottleneck is also 65 kph. The average space headway when vehicles are stationary is 12.5 m. The volume of traffic on the 3-lane road is 2700 vph. Assuming that the speed – concentration relation is linear, find:

1- The mean speed of traffic through the bottleneck caused by the closure of one lane;
2- The mean speed of traffic in the congested condition immediately on the approach to the bottleneck
3- The rate at which the queue of the congested traffic entering the bottleneck grows.

Problem 11/ Determine level of service by segment, for the entire length of the first three intersections and for the entire length of all intersections for one direction of flow for through lane group for a 2.0-mi divided multilane class I urban street (FFS=55mi/h) with 4 signalized intersections. The spacing and the control delay are as follows:

Segment	1	2	3	4
Delay (sec)	8.0	11.2	9.0	7.6
Spacing (mi)	0.35	0.4	0.6	0.65

Problem 12/ A four phase isolated pretimed (fixed time) signalized intersection has the following necessary data :

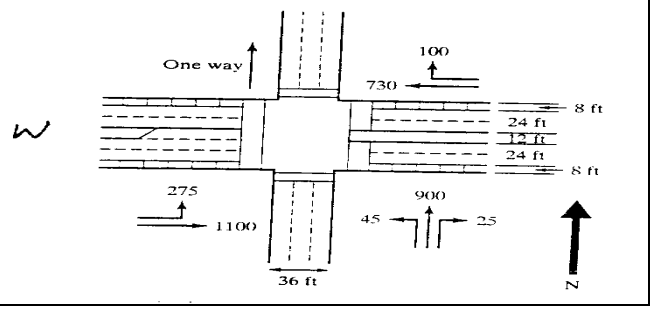
Duration of analysis period = 1 hour Saturation flow rate = 1750 veh/h Cycle length = 120 seconds Effective green for lane group 1 (phase 1) = 20 seconds Effective green for lane group 2 (phase 2) = 30 seconds Effective green for lane group 3 (phase 3) = 20 seconds	Effective green for lane group 4 (phase 4) = 30 seconds Demand volume for lane group 1 = 400 veh/h Demand volume for lane group 2 = 650 veh/h Demand volume for lane group 3 = 400 veh/h Demand volume for lane group 4 = 650 veh/h

Using HCM2000 method Find:

1- Capacity of each lane group using ci=si (gi/C) 2- Degree of saturation (X) for each lane group	3- Average control delay per vehicle for each lane group 4- Average control delay per vehicle for the intersection

Problem 13/ Develop a signal phase plan (design the timing plan with min. number of phases without cross conflict) for the intersection with layout and demand volumes shown in Figure below. The saturation flow rates are: 1750 pcphgpl for through, 1700 pcphgpl for right, 1650 pcphgpl for left, and 1670 pcphgpl for shared lanes. A 2 second all red interval is used

PHF = 0.92
Target v/c = 0.9
Avg. speed = 30 mi/h
Level grades



Problem 14/ The following spot speed data, collected from Zanco street in Arbil city. The standard deviation is computed and it is equal to 15.11 kph:

1- Compute the time mean speed and space mean speed.
2- What are the confidence limits on the estimate of the true mean speed with the following confidences: i- 85% ? ii- 99.7% ? iii- 50%
3- Based on the results of this study, a second study is to be conducted to achieve a tolerance of ± 1.5 kph with 90% confidence. What sample size is needed?
4- *Without* considering this data to be described as normal, find the probability of:
i- speeds < 40 kph ii- speeds > 40 kph iii- speeds between 50 kph and 70kph
5- What are the allowable speed limits?

Speed Groups (kph)	Middle speed (kph)	No. of vehicles in group	Percent frequency in group	Cumulative percent frequency	Col.3 x Col. 2	Col.3 / Col.2
10 - 20	15.0	0	0.00	0.00	0.00	0.000
20 - 30	25.0	3	1.91	1.91	75.00	0.120
30 - 40	35.0	6	3.82	5.73	210.00	0.171
40 - 50	45.0	18	11.46	17.20	810.00	0.400
50 - 60	55.0	45	28.66	45.86	2475.00	0.818
60 - 70	65.0	48	30.57	76.43	3120.00	0.738
70 - 80	75.0	18	11.46	87.90	1350.00	0.240
80 - 90	85.0	12	7.64	95.54	1020.00	0.141
90 - 100	95.0	4	2.55	98.09	380.00	0.042
100 - 110	105.0	3	1.91	100.00	315.00	0.029
110 - 120	115.0	0	0.00	100.00	0.00	0.000
Sum	715.00	157	100.00		9755.00	2.700

Problem 15/ The following two spot speed samples conducted at a test location to determine the effectiveness of a new speed limit posting at 80 kph.

Item	Before	After
Average speed (kph)	88.5	84.5
Standard deviation (kph)	8.0	9.0
Sample size	100	85

1- Was the new speed limit effective in reducing average speeds at this location?
2- Was the new speed limit effective in reducing average speeds to the posted speed limit (80 kph)?

Problem 16/ The data given below are the average values of six runs which were collected by a moving vehicle on a section of roadway. The test car is traveling at a speed of 46 kph northbound. The number of vehicles passed by the test car is more than the vehicles overtaking it by 2 vehicles in northbound and 3 vehicles southbound. Estimate for both directions:

1- The volume of the traffic stream.
2- The travel and running speeds
3- The density of the traffic stream.
4- The speed of the test car southbound

	Travel Time (sec)	Stopped Time (sec)	Vehicles Met
Northbound	70	7	100
Southbound	67	15	120

Problem 17/ The following data was collected during a control delay study on a 2 lane signalized intersection approach. The cycle length of the signal is 90 sec, the free flow speed=67 kph, the total number of vehicles arriving during the study period=200 vehicles, and the total count of stopping vehicles=100:

1- Determine the total vehicle-in-queue count.
2- Estimate the time spent in queue for the average vehicle
3- Estimate the average control delay per vehicle on this approach.

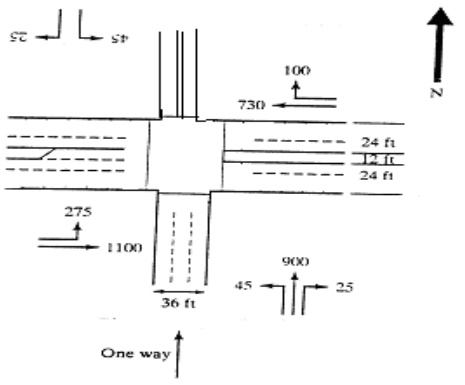
Clock Time	Cycle Number	Number of Vehicles in Queue					
		+0 s	+15 s	+30 s	+ 45 s	+60 s	+75 s
8:00 AM	1	2	4	2	1	4	3
	2	3	3	2	1	4	4
8:03 AM	3	3	2	4	2	5	6
	4	1	4	6	3	2	4
8:06 AM	5	5	5	4	5	6	7
	6	5	2	4	4	3	5
8:09 AM	7	4	3	3	2	3	3
	8	2	2	5	3	5	4
8:12 AM	9	1	2	2	4	2	4
	10	3	4	1	1	2	5
8:15 AM	11	3	5	3	4	4	3
	12	2	2	3	4	3	4

Problem 18/ Two lanes of a 4-lane two way highway were closed for repairs. Under conditions of low flow in the 4-lane position is 65 kph. Under conditions of low flow, observations show that the maximum mean free speed in the bottleneck is 60 kph. The average space headway when vehicles are stationary is 10.0 m. The volume of traffic on the 4 lane road is 800 vph per one lane and the jam density for two lanes is 200 vpk. Assuming that the speed – density relation is linear, and using Lighthill and Whithams theory find the mean speed of traffic on the carriageway clear of the influence of the bottleneck

Problem 19/ Determine the level of service for the segment with length composing of sum of lengths of the second and third intersections for one direction of flow for through lane group for a 1.8-mi divided multilane class I urban street (FFS=52mi/h) with 4 signalized intersections. The spacing and the control delay of the intersections are as given in Table below:

Segment	1	2	3	4
Spacing (mi)	0.3	0.50	0.4	0.6
Delay (sec)	10.0	9.6	8.0	12.6

Problem 20/ Define the lane groups and find the flow ratio (V/S) for all approaches of the intersection with layout and demand volumes shown in Figure. The peak hour factor is 0.90 and the saturation flow rates are: 1750 pcphgpl for through, 1700 pcphgpl for right, 1650 pcphgpl for left, and 1670 pcphgpl for shared lanes.



Problem 21/ Develop a signal phase plan with minimum number of phases without cross conflict for the intersection with the data given in the following Table. Assume a 3 seconds yellow interval and a 2 second all red interval. Draw and check all possible phase plans then choose the one which gives the lowest cycle time. For the lowest cycle time allocate a suitable green time for each phase and draw the time diagram using suitable scale.

Approach	N			E			S			W		
Lane group	L+Th	TH	R+Th	L	Th	R	L	TH	R+Th	L	TH	R+Th
(V/S)i	0.12	0.20	0.08	0.15	0.22	0.10	0.18	0.25	0.17	0. 19	0.23	0.11

Problem 22/ At a particular section of roadway the spot speeds were observed and tabulated as given in the following frequency table:

Speed (kph)	20 – 30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	100-110	110-120
frequency	4	6	36	60	71	84	65	45	22	5

If this data is assumed to be normally distributed, determine the:

1- Arithmetic mean speed(TMS)
2- Space mean speed (SMS)
3- Standard deviation
4- 50 percentile speed
5- Probability that the speed is > 70 kph
6- Probability that the speed is > the (mean + 5)
7- Probability that the speed lie between median and 30 kph

Problem 23/ On a certain road the speed - Flow relationship obtained was $Q = 150\ V_s - 1.2\ V_s^2$ Determine:

1- The free flow speed and the jam density
2- The capacity and the optimum speed.
3- The flow-density relationship
4- Using suitable scale draw the speed – flow curve and find the speed when the flow is 50 vph.

Problem 24/ One lane of a 3-lane one way carriageway is closed for repairs. The maximum mean free speed under conditions of low flow in the 3-lane position is 65 kph. Under conditions of low flow, observations show that the maximum mean free speed in the bottleneck is also 65 kph. The average space headway when vehicles are stationary is 12.5 m. The volume of traffic on the 3-lane road is 2700 vph. Assuming that the speed – concentration relation is linear, find:

1- The mean speed of traffic through the bottleneck caused by the closure of one lane;
2- The mean speed of traffic in the congested condition immediately on the approach to the bottleneck
3- The rate at which the queue of the congested traffic entering the bottleneck grows.

Problem 25/ Determine level of service by segment, for the entire length of the first three intersections and for the entire length of all intersections for one direction of flow for through lane group for a 2.0-mi divided multilane class I urban street (FFS=55mi/h) with 4 signalized intersections. The spacing and the control delay are as follows:

Segment	1	2	3	4
Delay (sec)	8.0	11.2	9.0	7.6
Spacing (mi)	0.35	0.4	0.6	0.65

Problem 26/ A four phase isolated pretimed (fixed time) signalized intersection has the following necessary data :

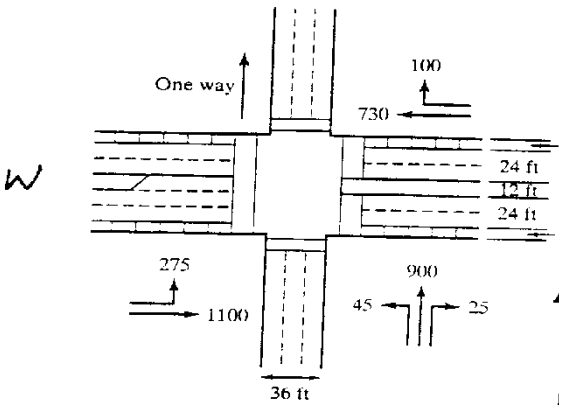
Duration of analysis period = 1 hour
Saturation flow rate = 1750 veh/h
Cycle length = 120 seconds
Effective green for lane group 1 (phase 1) = 20 seconds
Effective green for lane group 2 (phase 2) = 30 seconds
Effective green for lane group 3 (phase 3) = 20 seconds
Effective green for lane group 4 (phase 4) = 30 seconds
Demand volume for lane group 1 = 400 veh/h
Demand volume for lane group 2 = 650 veh/h
Demand volume for lane group 3 = 400 veh/h
Demand volume for lane group 4 = 650 veh/h
Using HCM2000 method Find:

1- Capacity of each lane group using ci=si (gi/C)
2- Degree of saturation (X) for each lane group
3- Average control delay per vehicle for each lane group
4- Average control delay per vehicle for the intersection

Problem 27/ Develop a signal phase plan (design the timing plan with min. number of phases without cross conflict) for the intersection with layout and demand volumes shown in Figure below. The saturation flow rates are: 1750 pcphgpl for through, 1700 pcphgpl for right, 1650 pcphgpl for left, and 1670 pcphgpl for shared lanes.

PHF = 0.92

Avg. Approach speed = 30 mi/h
Level grades



Problem 28/ At a particular section of roadway the spot speeds were observed and tabulated as given in the following frequency table:

Speed (kph)	20 - 30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	100-110	110-120
frequency	4	6	36	60	71	84	65	45	22	5

If this data is assumed to be normally distributed, determine the:

1- Arithmetic mean speed(TMS)
2- Space mean speed (SMS)
3- Standard deviation
4- 50 percentile speed
5- Probability that the speed is > 70 kph
6- Probability that the speed is > the (mean + 5)
7- Probability that the speed lie between median and 30 kph

Problem 29/ On a certain road the speed - Flow relationship obtained was $Q = 150\ V_s - 1.2\ V_s^2$ Determine:

1- The free flow speed and the jam density
2- The capacity and the optimum speed.
3- The flow-density relationship

Using suitable scale draw the speed – flow curve and find the speed when the flow is 50 vph.

Problem 30/ One lane of a 3-lane one way carriageway is closed for repairs. The maximum mean free speed under conditions of low flow in the 3-lane position is 65 kph. Under conditions of low flow, observations show that the maximum mean free speed in the bottleneck is also 65 kph. The average space headway when vehicles are stationary is 12.5 m. The volume of traffic on the 3-lane road is 2700 vph. Assuming that the speed – concentration relation is linear, find:

1- The mean speed of traffic through the bottleneck caused by the closure of one lane;
2- The mean speed of traffic in the congested condition immediately on the approach to the bottleneck
3- The rate at which the queue of the congested traffic entering the bottleneck grows.

Problem 31/ Determine level of service by segment, for the entire length of the first three intersections and for the entire length of all intersections for one direction of flow for through lane group for a 2.0-mi divided multilane class I urban street (FFS=55mi/h) with 4 signalized intersections. The spacing and the control delay are as follows:

Segment	1	2	3	4
Delay (sec)	8.0	11.2	9.0	7.6
Spacing (mi)	0.35	0.4	0.6	0.65

Problem 32/ A four phase isolated pretimed (fixed time) signalized intersection has the following necessary data :

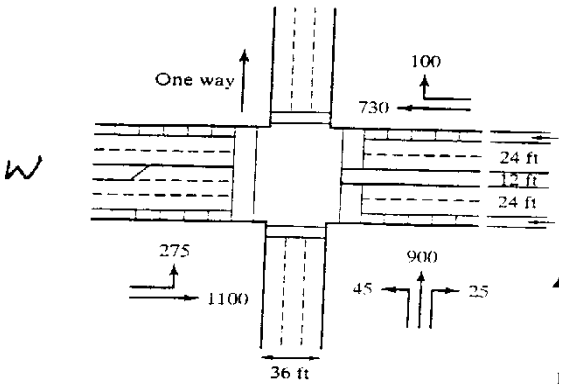
Duration of analysis period = 1 hour	Effective green for lane group 4 (phase 4) = 30 seconds
Saturation flow rate = 1750 veh/h	Demand volume for lane group 1 = 400 veh/h
Cycle length = 120 seconds	Demand volume for lane group 2 = 650 veh/h
Effective green for lane group 1 (phase 1) = 20 seconds	Demand volume for lane group 3 = 400 veh/h
Effective green for lane group 2 (phase 2) = 30 seconds	Demand volume for lane group 4 = 650 veh/h
Effective green for lane group 3 (phase 3) = 20 seconds	

Using HCM2000 method Find:

1- Capacity of each lane group using ci=si (gi/C)
2- Degree of saturation (X) for each lane group
3- Average control delay per vehicle for each lane group
4- Average control delay per vehicle for the intersection

Problem33/ Develop a signal phase plan (design the timing plan with min. number of phases without cross conflict) for the intersection with layout and demand volumes shown in Figure below. The saturation flow rates are: 1750 pcphgpl for through, 1700 pcphgpl for right, 1650 pcphgpl for left, and 1670 pcphgpl for shared lanes. A 2 second all red interval is used

PHF = 0.92
Target v/c = 0.9
Avg. speed = 30 mi/h
Level grades



Problem 34/ For the following spot speed data, the coefficient of variation and the 67 percentile speed are 23.06% and 65.84 kph respectively. Using the frequency distribution Table find:

1- The time mean speed, space mean speed and the standard error.
2- The probability of vehicles with speeds between 67 kph and 99 kph.
3- The allowable speed limits.

Speed Groups (kph)	Middle speed (kph), (x_i)	No. of vehicles in group , f_i	Percent frequency in group, %f	Cumulative percent frequency, %F	$f_i x_i$	f_i/x_i	$f_i(x_i\text{-TMS})^2$	$f_i(x_i\text{-SMS})^2$
15 - 25	20.0	0	0.00	0.00	0.0	0.00	0.0	0.0
25 - 35	30.0	4	3.08	3.08	120.0	0.13	3655.6	2865.2
35 - 45	40.0	14	10.77	13.85	560.0	0.35	5730.0	3934.3
45 - 55	50.0	27	20.77	34.62	1350.0	0.54	2826.1	1235.2
55 - 65	60.0	40	30.77	65.38	2400.0	0.67	2.1	419.0
65 - 75	70.0	25	19.23	84.62	1750.0	0.36	2385.9	4380.0
75 - 85	80.0	15	11.54	96.15	1200.0	0.19	5862.3	8098.9
85 - 95	90.0	5	3.85	100.00	450.0	0.06	4431.0	5523.3
95 - 105	100.0	0	0.00	100.00	0.0	0.00	0.0	0.0
Sum	540.0	130	100.00		7830.0	2.29	24893.1	26455.8

Problem 35/ Experience suggests that spot speed data at a given location is normally distributed with a mean of 85 kph and a standard deviation of 10 kph. What is :

1- The 97.5 percentile speed?
2- The probability of vehicles with speeds > 44 kph?
3- The range of the true mean for a spot speed sample of 100 vehicles?
4- The probability that the mean speed > 83 kph if a spot speed sample of 121 vehicles was observed?

Problem 36/ Develop a signal phase plan (design the timing plan with min. number of phases without cross conflict) for the intersection with layout and demand volumes shown in Figure below. The saturation flow rates are: 1750 pcphgpl for through, 1700 pcphgpl for right, 1650 pcphgpl for left, and 1670 pcphgpl for shared lanes. A 2 second all red interval is used The mean spot speeds of 100 vehicles observed on a Friday at a particular location of a highway was 74 kph and the standard deviation was 10 kph. The mean spot speeds of 45 vehicles observed on a Saturday at the same location was 70 kph and the standard deviation was 12 kph. The speed of all vehicles at this location as per previous records was normally distributed with a mean of 80 kph. Is there sufficient evidence to show that the speed of vehicles of the particular Friday is lower than the average speed

Problem 37/ The following data was collected during a control delay study on a signalized intersection approach started at 8:00 A.M. for 8 minutes using time interval between time-in-queue counts of 15 seconds. The cycle length of the signal was 60 sec; the total number of vehicles arriving during the study period was 120 vehicles, 80% of them which are stopping. The total vehicle-in-queue count was 144 vehicles. Estimate the average control delay per vehicle on this approach if the correction factor is +7.

Problem 38/ Develop a signal phase plan (design the timing plan with min. number of phases without cross conflict) for the intersection with layout and demand volumes shown in Figure below. The saturation flow rates are: 1750 pcphgpl for through, 1700 pcphgpl for right, 1650 pcphgpl for left, and 1670 pcphgpl for shared lanes. A 2 second all red interval is used The data given below are the average values of six test runs in each direction which were collected by a moving vehicle on a section length of 1.0 km on a roadway. The number of vehicles passed by the test car is more than the vehicles overtaking it by 1 vehicle in northbound and 4 vehicles southbound. Estimate the volume, travel and running speeds, and the density of traffic stream in both directions.

	Test car Travel speed (kph)	Stopped Time (sec)	Vehicles Met
Northbound	48	8	140
Southbound	40	14	150

Problem 39/ On a certain road the density – speed - flow data obtained are as given in the following Table. Find the correlation coefficient between the speed and the density, then using Greenshield`s linear traffic flow model:

1- Determine the free flow speed and the jam density.
2- Determine the capacity and the optimum speed.
3- Determine the speed when the density is equal 100 vpk.
4- Using suitable scale draw the curves of the basic traffic parameters.
5- What is the coefficient of determination for the various parameters that can be obtained from the model?

Speed (kph)	90	85	75	65	45	25	20	15
Density (vpk)		47		68		119		133
Flow (vph)	3600		4275		4275		2560	

Problem 40/ Two lanes of a 5-lane one way carriageway are closed for repairs. The maximum mean free speed under conditions of low flow in the 5-lane position is 60 kph and in the bottleneck it is 50 kph. The average space headway when vehicles are stationary is 10 m. The volume of traffic on the 5-lane road is 1000 vph/lane. Assuming that the speed – density relation is linear, find:

1- Draw the flow - density curves for the traffic clear of the bottleneck and in the bottleneck.
2- The mean speed of traffic on the carriageway clear of the influence of the bottleneck.
3- The mean speed of traffic through the bottleneck caused by the closure of two lanes.
4- The mean speed of traffic in the congested condition immediately on the approach to the bottleneck.
5- The rate at which the queue of the congested traffic entering the bottleneck grows.

Problem 41/ Determine level of service for one direction of flow for through lane group for a 1.5-mi divided multilane class I urban street (FFS=55mi/h) with 4 signalized intersections as follows:

1- By segment,
2- For the entire length of the last two intersections
3- For the entire length of all intersections

The spacing and the control delay are as follows:

Segment	1	2	3	4
Delay (sec)	10.0	12.0	9.0	8.0
Spacing (mi)	0.25	0.4	0.5	0.35

Problem 42/ What are:

1- Microscopic traffic parameters
2- Factors affecting capacity and LOS
3- Types of intersection control

Show if the following spot speed data may be considered to be normally distributed using chi-squared test, then find the number of vehicles not traveling within the allowable speed limits.

Speed groups kph	40 – 50	50 – 60	60 – 70	70 – 80	80 – 90	90 – 100	100 – 110	110 – 120
f_o	4	19	33	52	57	27	12	3
f_t	4.3	15.6	36.7	52.6	51.2	30.5	11.9	2.9

Problem 43/ Convert the following summary table (which is the design hour traffic flows at a 4 – arm intersection) to a graphic summary intersection sheet.

From South			From West			From North			From East		
L	S	R	L	S	R	L	S	R	L	S	R
60	600	60	70	700	70	65	650	65	75	750	75

Problem 44/ Six runs were made in each direction along a section of 1000m length of a two way street. Data was collected northbound and southbound as shown in the following Table (average of 6 runs). Calculate (for northbound direction) the flow and the average travel speed of traffic if the test car travels at a speed greater than the speed of the traffic stream and the difference between the overtaking and passed traffic is 3 vehicles.

Time (minutes)		Vehicles met (opposing direction)	
Northbound	Southbound	Northbound	Southbound
2.5	2.7	200	150

Problem 45/ The mean spot speed observed on a particular day at a particular location of a highway was 60 kph and the standard deviation was 10 kph. The speed of vehicles for all days at this location was 55 kph. Is there sufficient evidence to show that the speed of vehicles of that particular day was different from the average speed for sample size of 25 vehicles?

Problem 46/ On a certain road the flow - speed relationship obtained was $v = 140\ S - 1.3\ S^2$ Determine:

1- The free flow speed and the jam density
2- The optimum density and the optimum speed
3- The capacity.
4- The flow-density relationship
5- The average decrease in speed for each 10 vpk increase in density.

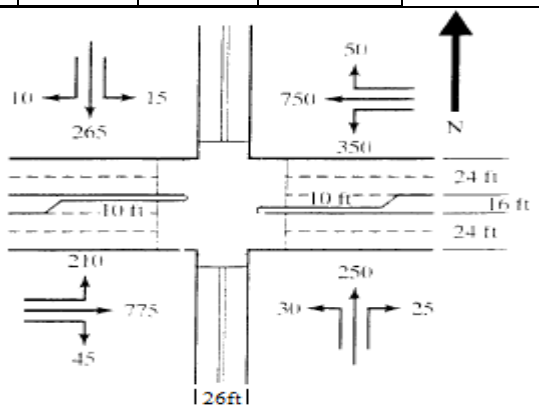
Problem 47/ Determine level of service for segments 2 and 3 for one direction of flow for through lane group of a 1.8-mi divided multilane class I urban street (FFS=50mi/h) with 4 signalized intersections. The spacings for each of the first and third intersections are 0.5 mi, while for the second and fourth intersections are 0.4 mi. The control delay is as follows:

Segment	1	2	3	4
Control Delay (sec)	11.0	10.6	6.0	5.6

Problem 48/ The following data was collected during a control delay study on a 2 lane signalized intersection approach between 9:00 A.M. to 9:09 A.M. The free flow speed = 44 kph, the total number of vehicles arriving during the study period=200 vehicles, and the total count of stopping vehicles = 100. Estimate the average control delay per vehicle on this approach.

Cycle Number	Number of Vehicles in Queue					
	+0 s	+15 s	+30 s	+ 45 s	+60 s	+75 s
1	3	3	2	2	5	2
2	2	4	2	1	4	4
3	3	2	4	2	5	6
4	1	4	6	3	2	4
5	5	5	4	5	6	7
6	5	2	4	4	3	5

Problem 49/ Develop an isolated pretimed (fixed time) signal phase plan (design the timing plan with minimum number of phases without cross conflict) for the intersection with layout and demand volumes shown in Figure below. The peak hour factor is 0.90 and the saturation flow rates are: 1750 pcphgpl for through, 1700 pcphgpl for right, 1650 pcphgpl for left, and 1670 pcphgpl for shared lanes. Total lost time per phase is equal to 7 seconds. Use the ITE approach to determine the yellow and all red intervals. Draw the time and phase plans.



Problem 50/ What are the:

1- Objectives of traffic engineering?
2- Factors affecting spot speed?
3- Elements in volume variations?
4- Types of vehicle delay?

Problem 51/ At a particular section of roadway the spot speeds were observed and tabulated as given in the following frequency table:

Speed group (kph)	20 - 30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	100-110	110-120
frequency	4	6	36	60	71	84	65	45	22	5

If this data is assumed to be normally distributed:

1- What is the 80 percentile confidence interval for the mean speed
2- What is the 70 percentile confidence interval for the speeds
3- Find the probability that the mean speed >60 kph
4- The probability that the speed lie in speed group of the mean.

Problem 52/ Convert the following summary table (which is the design hour traffic flows at a 4 – arm intersection) to intersection flow diagram.

From South			From West			From North			From East		
L	S	R	L	S	R	L	S	R	L	S	R
60	600	60	70	700	70	65	650	65	75	750	75

Problem 53/ On a certain road the density – speed data obtained were as follows:

Speed (kph)	110	90	95	75	65	45	25
Density (vpk)	15	30	37	68	75	95	120

Find the correlation coefficient between the speed and the density. Using Greenshield`s linear traffic flow model find the speed–density, speed-volume and volume-density equations then plot their curves on one graph. What is the coefficient of determination for the various parameters that can be obtained from the model?

Problem 54/ One lane of a 3-lane one way carriageway is closed for repairs. The maximum mean free speed under conditions of low flow in the 3-lane position is 65 kph, while in the bottleneck is 55 kph. The average space headway when vehicles are stationary is 12.5 m. The speed and density of traffic on the three-lane road are 45kph and 20vpk/lane respectively. Assuming that the speed–density relation is linear, determine:

1- The mean speed of traffic through the bottleneck caused by the closure of one lane;
2- The mean speed of traffic in the congested condition immediately on the approach to the bottleneck
3- The rate at which the queue of the congested traffic entering the bottleneck grows.

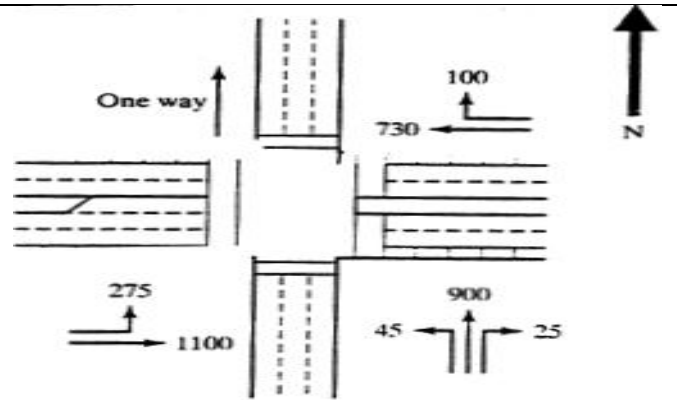
Problem 55/ Determine level of service by segment, for the entire length of the first three intersections and for the entire length of all intersections for one direction of flow for through lane group for a divided multilane urban street (FFS=40mi/h) with 4 signalized intersections. The spacing and the control delay are as follows:

Segment	1	2	3	4
Delay (sec)	8.0	11.2	9.0	7.6
Spacing (mi)	0.20	0.40	0.30	0.75

Problem 56/ At a highway location with poor geometrics, the mean spot speed observed at a particular day with a sample of 200 vehicles was 58.3 kph with a standard deviation of 12.2 kph. After effecting improvements to the geometrics, the mean speed observed at another particular day with a sample of 250 vehicles was 61.2kph with a standard deviation of 9.8 kph. Has there been a significant:

1- Difference in the speed after the improvements?
2- Increase in the speed after the improvements?

Problem 57/ Develop an isolated pretimed (fixed time) signal phase plan (design the timing plan with minimum number of phases without cross conflict) for the intersection with layout and demand volumes shown in Figure below. The peak hour factor is 0.90 and the saturation flow rates are: 1750 pcphgpl for through, 1700 pcphgpl for right, 1650 pcphgpl for left, and 1670 pcphgpl for shared lanes. Assume all red interval =3.0 sec and yellow interval = 4.0 sec.



Problem 58/ At a particular section of roadway the spot speeds were observed and tabulated as given in the following frequency table:

Speed groups Kph	40 – 50	50 – 60	60 – 70	70 – 80	80 – 90	90 – 100	100 – 110	110 – 120
f_o	4	19	33	52	57	27	12	3
f_t	4.3	15.6	36.7	52.6	51.2	30.5	11.9	2.9

Determine the 50 percentile speed, the probability that the speed > 50, and the probability that the speed lies in the speed group of the median:

5- Using the frequency table
6- If this spot speed data is suggested to be normally distributed

Problem 59/ Six runs were made in each direction along a section of 1500 m length of a two way street. Data was collected northbound and southbound. The calculations showed that the average travel speed of the test car is 45 kph both directions. Calculate (for both directions) the flow rate of the traffic if the test car travels at a speed 10 kph higher than the speed of the traffic stream in northbound and 10 kph lower than the speed of traffic stream southbound. The difference between the overtaking and passed vehicles in both directions is 3 vehicles.

Problem 60/ On a certain road the speed - density data obtained from Greenshield`s linear traffic flow model was S = 120 – D:

1- Determine the speed-flow and the density-flow relationships
2- Tabulate the calculated (predicted) values of the dependent variable for the three relationships (speed-density, speed –flow and density-flow)

Problem 61/ At a highway location with poor geometrics, the mean spot speed observed at a particular day with a sample of 200 vehicles was 58 kph with a standard deviation of 10 kph. After effecting improvements to the geometrics, the mean speed observed at another particular day with a sample of 250 vehicles was 61 kph with a standard deviation of 8.0 kph. Has there been a significant increase in the speed after the improvements?

Problem 62/ The mean spot speed observed at a street is known to be normally distributed with a mean speed of 60 kph. Another sample using new method was used for observing the spot speed at the same location and a set of 22 observations was obtained. The mean speed was 58 kph with a standard deviation of 10 kph. Using statistical methods, show that if the mean speed of the second method differs from the mean speed at this location?

Problem 63/ Two lanes of a 5-lane one way carriageway were closed due to traffic accident. The maximum mean free speed under conditions of low flow in the 5-lane position is 60 kph and in the bottleneck it is 50 kph. The average space headway when vehicles are stationary is 10 m. The volume of traffic on the 5-lane road is 1000 vph/lane. Assuming that the speed – density relation is linear, draw the flow - density curves for the traffic clear of the bottleneck and in the bottleneck then find:

1- The mean speed of traffic on the carriageway clear of the influence of the bottleneck.
2- The optimum density on the carriageway clear of the influence of the bottleneck.
3- The mean speed of traffic through the bottleneck caused by the closure of two lanes.
4- The optimum density of traffic through the bottleneck caused by the closure of the two lanes..
5- The mean speed of traffic in the congested condition immediately on the approach to the bottleneck.
6- The rate at which the queue of the congested traffic entering the bottleneck grows.

Problem 64/ Determine level of service for one direction of flow for through lane group for a 1.5-mi divided multilane class I urban street (FFS = 55mi/h) with 4 signalized intersections as follows:

1- By segment,
2- For the entire length of the last two intersections
3- For the entire length of all intersections

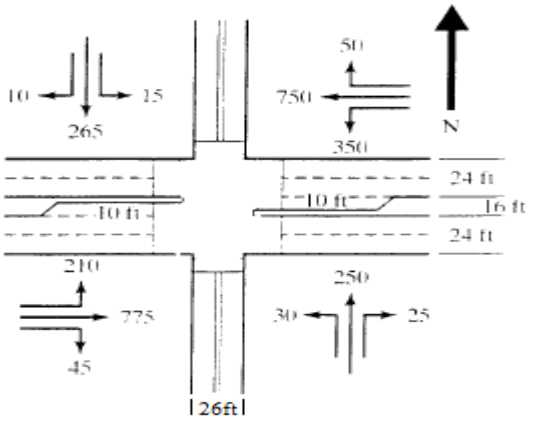
The spacing and the control delay are as follows:

Segment	1	2	3	4
Delay (sec)	10.0	12.0	9.0	8.0
Spacing (mi)	0.25	0.4	0.5	0.35

Problem 65/ For the intersection with layout and demand volumes shown in the following Figure:

1- Define the lane groups for all approaches (give details in Table and Figure)
2- Determine the yellow and all red intervals for all approaches
3- Determine the total lost time for the intersection

PHF = 0.92
Target v/c = 0.9
Average speed = 30 mi/h
Level grades
Moderate Pedestrian volumes (equivalent = 1.32)
Average speed = 45 mi/h (all approaches)
Deceleration rate = 10 ft / s^2



Problem 66/ Answer the following briefly:

1- List the objectives of traffic engineering.
2- What are the types of graphs used in graphical presentation of spot speed data? Explain the traffic parameters used in their axes.
3- What are the basic strategies that may be employed to improve traffic safety?

Problem 67/ The spot speeds of vehicles at a particular location on a highway are known to be normally distributed with a mean of 85 kph and a standard deviation of 10 kph. For a sample size of 100 vehicles, find:

1- The probability that the mean speed observed will exeed 99 kph.
2- The 99% confidence interval for the population mean
3- The significance level (α) for the above sample size of 100 vehicles if a level of tolerable error of ± 1.0 was used.

Problem 68/ The following two spot speed samples were conducted at a location to determine the effectiveness of improving geometrics at this location. Were the improvements effective in increasing average speeds at this location?

Item	Before	After
Average speed (kph)	60	64
Standard deviation (kph)	8.0	9.0
Sample size	120	125

Problem 69/ Eight runs were made in each direction along the two way street between Kurdistan int. and college of engineering which is 900 m long. Data was collected both north and south directions as follows (average of 8 runs):

	Speed of Traffic stream (kph)	Vehicles met (opposing direction)	Vehicles in the same direction	
			overtaking	Overtaken
North	40	100	4	4
South	35	90	3	3

Determine the flow of traffic for both directions if the test car travels at the mean speed of traffic.

Problem 70/ On a highway the number of vehicles arriving from one direction in successive 10 seconds intervals was counted and recorded as given in the following table. Does the data suggest that the arrival pattern can be considered as Poisson?

Vehicles arriving in 10 second intervals	0	1	2	3	4	5	6	7 and over
Frequency	11	28	30	18	8	4	1	0

Problem 71/ What are the types of signs? Draw 2 signs indicating the colors used on the drawings.

Problem 72/ A parking study for 12-hour of an area with 1500 total stalls and accumulation interval of 30 minutes, reverted that there were 450 space for 12-hours, 150 spaces available for 7-hours, 280 spaces available for 6 hours, and 100 spaces available for 5- hours. The duration distribution was as given in the following table:

	Number of intervals parked					
	1	2	3	4	5	6
Totals	875	490	308	275	143	28

Determine the average parking duration, parking supply, and the parking turnover.

Problem 73/ What are the:

1- Objectives of traffic engineering
2- Factors affecting spot speed
3- Elements in volume variations

Problem 74/ The spot speeds of vehicles at a particular location on a highway are known to be normally distributed with a mean of 50 kph and a standard deviation of 8 kph. For a sample size of 33 vehicles, find:

1- The probability that the modal speed will exeed 55 kph.
2- The probability that the median speed will exeed 50 kph.
3- The probability that the speed lies between the median and the mean speeds.
4- The 85 percentile speed.
5- The probability that the speed lies between the median and 15 percentile speed.
6- The 99% confidence interval for the
7- The significance level (α) for the above sample size of 33 vehicles if a level of tolerable error of ± 1.0 was used.

Problem 75/ On a certain road the flow - speed relationship obtained was $V = 148\ S - 1.17\ S^2$ Determine:

1- The free flow speed and the jam density.
2- The optimum speed and the optimum density.
3- The traffic capacity.
4- The flow-density relationship

Draw the relationships using suitable scale.

Problem 76/ Eight runs were made in each direction along a section of a two - way street having a length of 1000 m. The collected data showed that the speed of the traffic northbound was 50 kph while the speed of the test car southbound was 45 kph. Other details are given in the following Table (average of 8 runs). Determine the flow of traffic in both directions

	Vehicles met (opposing direction)	Vehicles in the same direction	
		overtaking	Overtaken
North	200	11	11
South	100	13	13

Problem 77/ On a highway the number of vehicles arriving from one direction in successive 15 seconds intervals was counted and recorded as given in the following table. If the data suggests that the arrival pattern could be considered as Poisson distribution, Find the mean rate of arrivals and the probability of arrival of 3vehicles or less in the given interval.

Vehicles arriving in 10 second intervals	0	1	2	3	4	5	6	7 and over
Frequency	11	28	30	18	8	4	1	0

Problem 78/ What are the types of traffic control devices? Draw 2 devices indicating the colors used on the drawings.

Problem 79/ The mean spot speeds of 30 vehicles observed on a holiday at a particular location of a highway was 70 kph and the standard deviation was 8.0 kph. The mean spot speed of all vehicles at this location as per previous records was 67 kph. Is there sufficient evidence to show that the speed of vehicles of the particular holiday is higher than the mean speed.

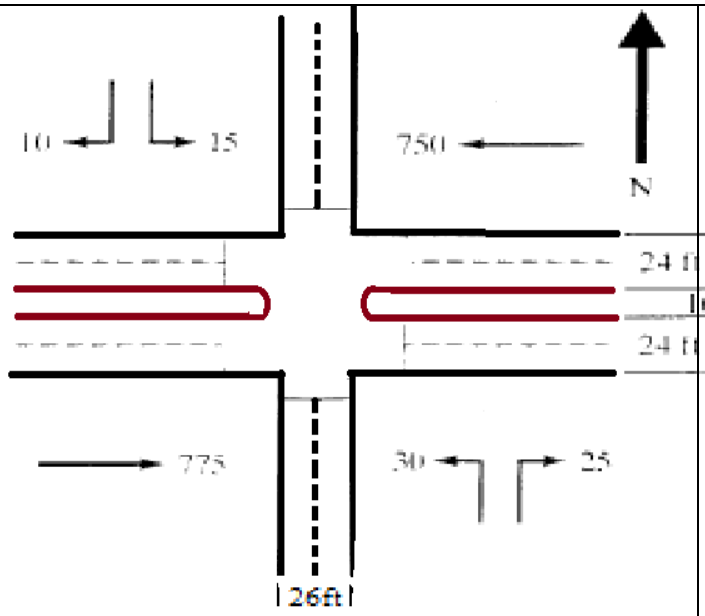
Problem 80/ For a parking area having the following details, determine the average parking duration, parking supply, and the parking turnover.

Parking details:

- total stalls = 1400
- study period 10-hours
- accumulation interval = 30 minutes
- available spaces: 300 spaces for 10-hours, 190 spaces available for 7-hours, 180 spaces available for 6 hours, and 100 spaces available for 5- hours
- The duration distribution was as given in the following table:

	Number of intervals parked					
	1	2	3	4	5	6
Totals	700	500	300	300	100	10

Problem 81/ Design isolated pretimed (fixed time) signal timing with minimum number of phases without cross conflict for the intersection with layout and data shown in the following Figure using equalizing saturation flow rate method. Draw and check all possible phase plans then choose the one which gives the shortest cycle time. Show the details in Tables and Figures. For the shortest cycle time allocate suitable green time for each phase and draw the time diagram using suitable scale.



PHF = 0.88
Target v/c = 0.90
Level grades
Moderate Pedestrian volumes (equivalent = 1.32)
Average speed (E – W)= 35 mi/h
Average speed (N - S) = 40 mi/h

Saturation flow rates:
Through = 1750 pcphgpl
Right turning = 1710 pcphgpl
Left turning = 1700 pcphgpl
Shared lanes 1670 pcphgpl for.