LAB EXERCISES IN TRAFFIC ENGINEERING

by

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Major Professor

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Document

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I am thankful to Mrs. Peggy J. Selvidge, our departmental secretary, who has typed this material and in spite of its volume, enabled me to present it on time.

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INTRODUCTION

The purpose of this report is to equip the Department of Civil Engineering at Kansas State University with a set of lab exercises to be used for an M. S. course, Traffic Engineering I. Excepting "Highway Capacity" all topics covered in the course have been included in 9 Chapters as below:

- I Volume Studies
- II Speed Studies
- III Travel Time and Delay Studies
 - IV Intersection Delay Studies
 - V Intersection Sight Distances
- VI Traffic Signal Systems and Networks
- VII Parking Studies
- VIII Intersection Design and Control
 - IX Accident Studies
- 2. Efforts were made to collect data used in exercises from real life situations and local conditions to give the student a feel of the types and dimensions of problems he may be called upon to tackle in his profession.

 Field exercises were undertaken in Manhattan, for Speed and Travel Time and Delay Studies while real data from published studies have been used in problems on Parking and Accident Studies. Data from field-surveys conducted in Manhattan during Traffic Engineering and Safety Seminar held at Kansas State University in May, 1975, has been used for an exercise on Intersection Volume Studies. In a few exercises of supplemental value, where the aim has been to clarify the definitions of various significant terms, data have been fabricated. Statistical checks have been applied to test the validity of data used in exercises on Speed Studies and Travel Time and Delay Studies.

3. Care has been taken to limit the scope of each problem so that a student could work out its solution in one or two three-hour lab sessions. Actual solutions will depend upon availability of funds, equipment and personnel with the organization and will involve various administrative and community decisions like demolition of structures, aesthetic requirements of a city, trade-offs involved at various stages in long-range solutions, coordination with concerned agencies, expectation level of people and public reaction to any suggested changes.

Some of the problems could perhaps be taken up as class projects in Traffic Engineering II course. Such projects will be more meaningful if the association of the concerned city department is sought, and in that case it may perhaps be necessary to modify the scope of such problems to accommodate the requirements of the city.

4. Most commonly occurring type of problems have been chosen for various chapters.

Volume Studies contain three problems, one on computation of AADT from coverage counts using daily and seasonal expansion factors, one on setting up a traffic counting schedule for the city of Manhattan and one on intersection volume studies.

Speed Studies include six problems. The first four problems involve various analyses of spot speed data and the last two require computation of Time Mean Speed and Space Mean Speed. A knowledge of the precise distinction between the two mean speeds is very necessary to a traffic engineer. It is most important that the same mean should be used throughout any investigation so that all comparisons are fair. There is a danger that a comparison of mean speeds measured some years apart, or by different investigators will be invalid, because they are not of the same kind.

A problem on Travel Time and Delay Studies requires detailed analysis of travel time study data collected by the average car method while another problem defines commonly used terms for various types of delays and speeds.

Intersection Delay Studies include a problem detailing the calculator method. The problem of visibility at intersections has been approached in an exercise on Intersection Sight Distances. Detailed notes prepared by Northwestern University on Intersection Sight Distances have been enclosed with the problem statement. A problem requiring use of sight angle board to determine safe approach speed(s) has been set up as a field exercise.

Time space diagrams have been used for timing the progression system for a balanced and for a preferential situation in the chapter on Traffic Signal Systems and Networks.

An exercise on Parking Studies requires analysis of usage and turn-over study data, while another exercise involves the design of a parking lot with the objective of providing maximum number of spaces.

Another problem, the partial design of a diamond interchange, requires the use of a technique developed by the Texas Transportation Institute, which includes the use of probability of cycle failure curves for cycle split.

Lastly, a problem on Accident Studies requires complete analysis of a set of accident reports on a high accident intersection to set up a step by step approach to remedial measures for improving the accident situation at this location.

Dept. of Civil Engineering Kansas State University Manhattan, Kansas 66506

subject

LAB EXERCISES IN TRAFFIC ENGINEERING

title

VOLUME STUDIES - PROBLEM STATEMENT

Attached is a set of hourly traffic volume data, recorded in the vicinity of downtown, and counts at key and master stations.

Compute Peak Hour Volumes, AADT for each station based on 24-hr. as well as short counts, and analyze the data as required in the problem-statement.

The procedures to be used in the solution may be studied in the following references:

- 1. "Measuring Traffic Volumes," NCUT Procedure Manual 3A.
- "Traffic Engineering Theory & Practice", by
 J. Pignataro Chapter 9.
- 3. "Fundamentals of Traffic Engineering", by Kennedy, Kell and Homburger Chapter 4.

PROBLEM 1

Vehicular traffic volumes were recorded, hourly, for 24-hour periods at several locations in the vicinity of downtown, during summer. The attached table lists hourly volumes for Station A for each of three weekdays (W, Th, F). Shown also are 24-hour counts for Stations B, C, and D.

- 1. Compute peak hour volume for each of the 24-hour counts, as a percentage of the total 24-hour volume.
- 2. Assume that Station A is a control station for Stations B, C, and D, and that the count at Station B was made on Wednesday, that at Station C on Thursday and that at Station D on Friday. From a Key Station count, we get the following information on 24-hour volumes at that Key Station for the same days that the control station was operating.

Sunday	3846	Thursday	4608
Monday	4023	Friday	4284
Tuesday	4069	Saturday	4414
Wednesday	3927	20.00-0010.001 **0.0010+000.0010 ± 0.001	

and, from our Master Count Station we get the following data,

AADT = 5456

and, the 24-hour volumes at the Master Station for the same days of the week that the key station operates are

Sunday	5860	Thursday	6785
Monday	6073	Friday	6312
Tuesday	6114	Saturday	6498
Wednesday	5970		

Compute the AADT for the Key Station, Control Station A and Stations B, C, and D.

- Compute the AADT for Stations B, C, and D assuming that counts were only made at B, C, and D for the following periods, on their respective day of operation,
 - a. Counts at B, C, and D for the two-hour period of 9-10 a.m. and 2-3 p.m.
 - b. Counts at B, C, and D for the four-hour period of 7-9 a.m. and 4-6 p.m.
 - c. Counts at B, C, and D for the eight-hour period of 7-11 a.m. and 2-6 p.m.
 - d. Counts at B, C, and D for the five-hour period of 1-6 p.m.

- 4. Compute the 24-hour volume of traffic at B, C, and D from the short counts for the day of operation of Stations B, C, and D. What is the percent variation between estimated and actual 24-hour volume for each short count case?
- 5. Comment on the following,
 - a. Differences in traffic flow patterns of streets A,
 B, C, and D. (Plotting hourly values as percentage of 24-hour values will aid in identifying differences.)
 - b. Relative accuracy of the different short-count methods in estimating 24-hour volumes.

Table I-1
HOURLY TRAFFIC VOLUMES AND PERCENTAGES
OF TOTAL DAILY TRAFFIC AT DIFFERENT LOCATIONS

	Street A				Other Streets							
Time	A	w	A	Th	A	F	В	W	C,	Th	I	F
	Vol.	%	Vol.	%	Vol.	%	Vol.	% .	Vol.	%	Vol.	%
12-1 A	90	1.3	133	1.6	119	1.5	59	1.4	84	2.0	156	1.5
1-2	35	0.5	58	0.7	62	0.8	19	0.5	39	0.9	58	0.5
2-3	9	0.1	29	0.3	21	0.3	13	0.3	11	0.3	23	0.2
3-4	5	0.1	10	0.1	9	0.1	5	0.1	7	0.2	11	0.1
4-5	9	0.1	9	0.1	7	0.1	3	0.1	2	0.1	11	0.1
5-6	9	0.1	9	0.1	8	0.1	10	0.2	9	0.2	12	0.1
6-7	52	0.8	45	0.5	40	0.5	41	1.0	21	0.5	73	0.7
7-8	509	7.4	473	5.7	359	4.6	219	5.3	246	6.0	557	5.1
8-9	523	7.6	657	7.9	613	7.9	219	5.3	412	10.0	771	7.1
9-10	358	5.2	431	5.2	441	5.7	224	5.4	173	4.2	682	6.3
10-11	395	5.7	485	5.8	424	5.5	168	4.1	160	3.9	571	5.2
11-12	468	6.8	481	5.8	458	5.9	238	5.7	149	3.6	643	5.9
12-1 P	487	7.1	618	7.4	576	7.4	233	5.6	242	5.9	701	6.4
1-2	438	6.3	512	6.1	477	6.2	217	5.2	202	4.9	649	6.0
2-3	365	5.3	491	5.9	440	5.7	254	6.1	192	4.6	619	5.7
3-4	442	6.4	538	6.4	453	5.9	277	6.7	199	4.8	668	6.1
4-5	515	7.5	656	7.8	593	7.7	337	8.1	331	8.0	829	7.6
5-6	647	9.4	727	8.7	657	8.5	394	9.5	484	11.7	1166	10.7
6-7	375	5.4	463	5.5	471	6.1	277	6.7	291	7.0	668	6.1
7-8	347	5.0	434	5.2	411	5.3	269	6.5	242	5.9	579	5.3
8-9	258	3.7	359	4.3	478	6.2	198	4.8	183	4.4	460	4.2
9-10	` 214	3.1	310	3.7	265	3.4	186	4.5	162	3.9	343	3.2
10-11	188	2.7	264	3.2	183	2.4	168	4.1	156	3.8	372	3.4
11-12	167	2.4	171	2.0	171	2.2	114	2.8	133	3.2	277	2.5

24 hr.
Totals 6905 100.0 8363 100.0 7736 100.0 4142 100.0 4130 100.0 10899 100.0

PROBLEM 2

The enclosed map of the City of Manhattan shows the existing physical street system. You are required to locate the following traffic counting stations and set up a 1-year schedule of counting for the various types of counting stations.

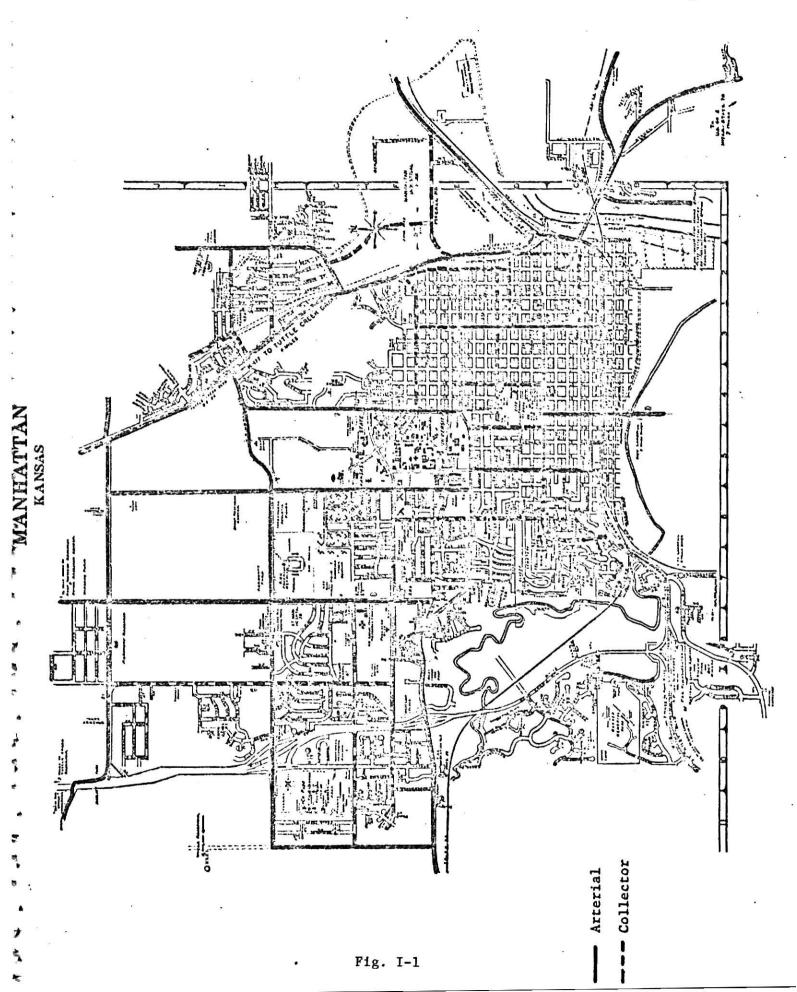
- 1. Major Control Stations
- 2. Minor Control Stations
- 3. Key Stations
- 4. Coverage Count Stations

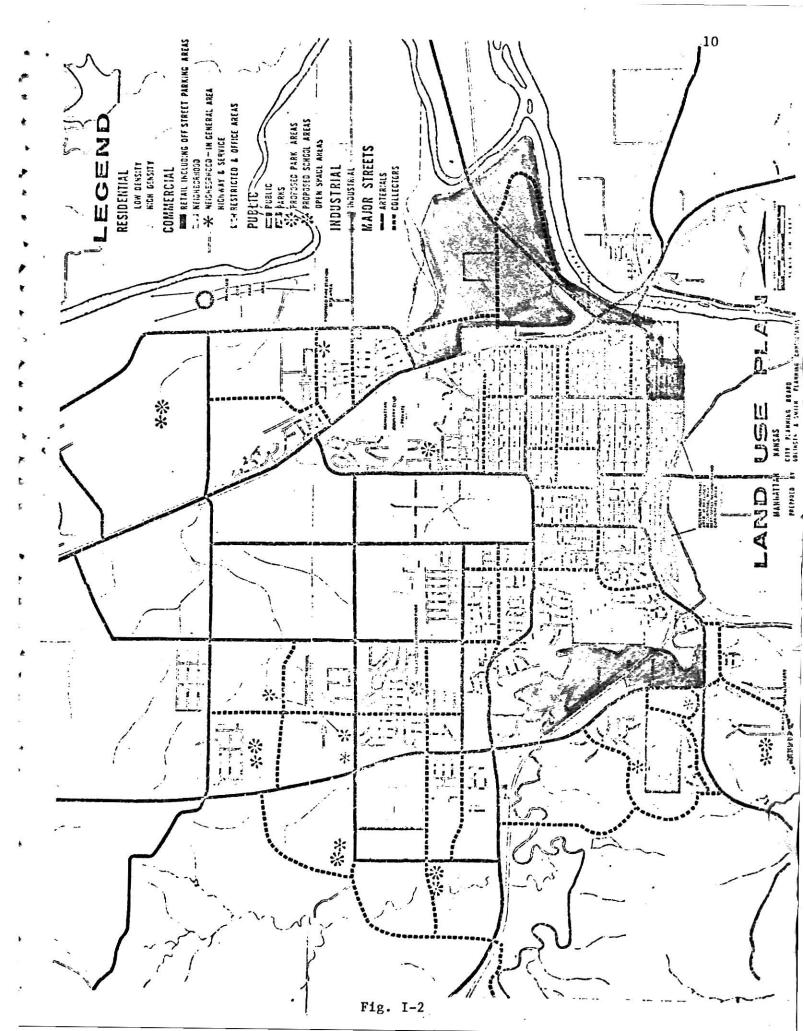
Also, locate,

- 1. Central Traffic District Cordon Line
- 2. Screen Line

Norms and principles laid down in NCUT procedure manual 3A -"Measuring Traffic Volumes" and in Chapter 9 of text, for locating the above counting stations and lines, may be followed. Different stations may be shown with different dots on the map.

For this problem, it may be assumed that the city is developing a systematic traffic volume counting program for the first time, and only the stationary count method is used for coverage counts.





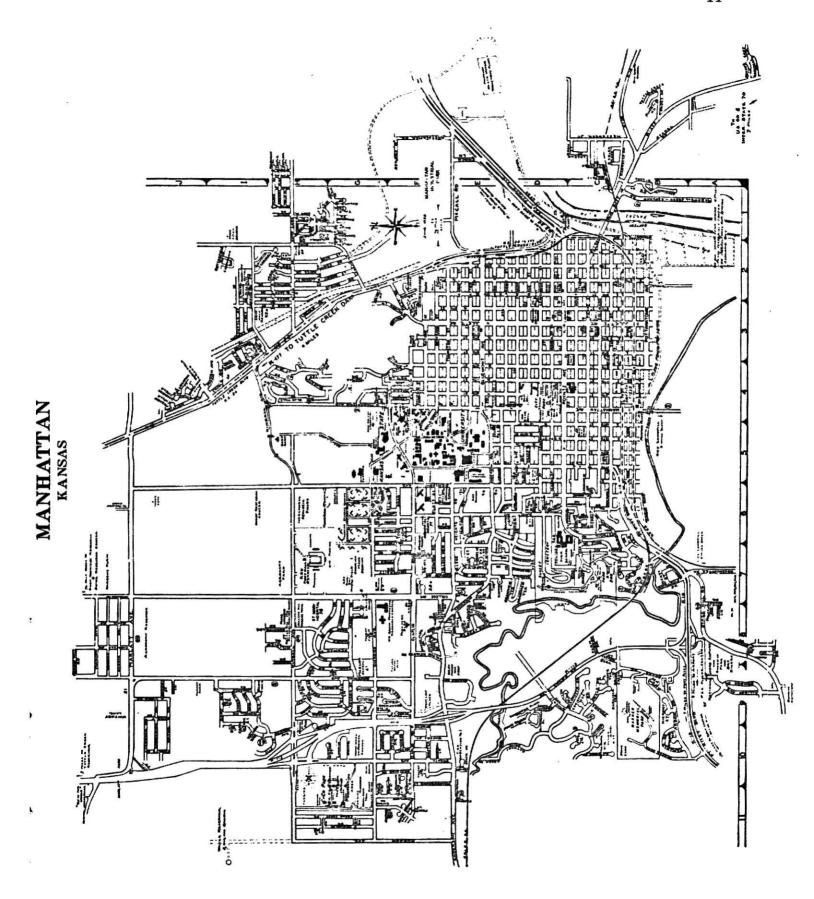


Fig. I-3

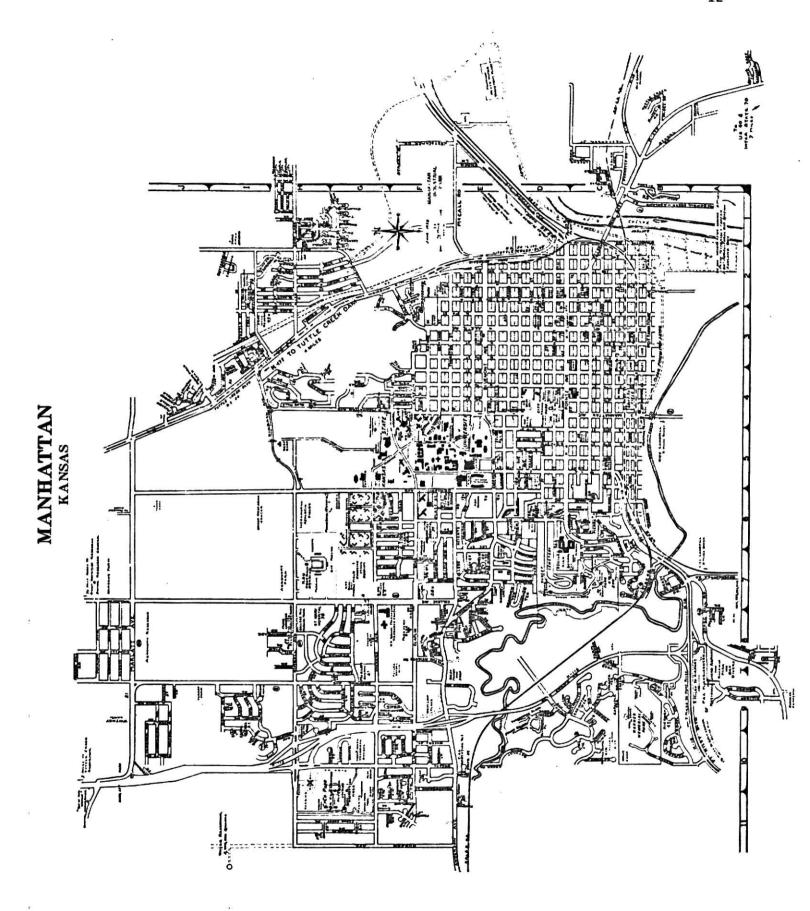


Fig. I-4

PROBLEM - 3

To study the efficiency of traffic operations on the intersection of Anderson and Sunset, all vehicular movements by five-minute increments were counted and recorded on May 15, 1975, from 3:30 P.M. to 5:30 P.M. All the four approaches of the said intersection were counted. Traffic Volumes as recorded are enclosed on traffic volume field sheets. You are required to summarize and tabulate volume data on the following sheets, for all approaches.

- (i) Approach Volume Summary Sheet TM-5
- (ii) Traffic Volume Summary Sheet TM-3
- 2. Analyze the data to determine the following:
 - (i) Determine the peak hour (the 12 consecutive five-minute increments containing the greatest total volume of traffic). Use TM-5.
 - (ii) Prepare a graphic summary on TM-3, for that hour, for each approach.
 - (iii) Determine the peak 15 minutes on each approach within the peak hour.
 - (iv) Calculate the peak hour factor for each approach.
 - (v) Determine the percentage of left and right turning vehicles, on each approach for the peak hour.

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Approach WB	Time Start this Sheet 5 10
Sheet Sheet Of 3	Cycle Length 50 Sec

Time	Left (L)	Straight (S)	Right (R)	Total (T)	Loaded Cycle
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Team No. 7-8

Recorder

APPROACH VOLUME SUMMARY SHEET

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APPROACH VOLUME SUMMARY SHEET

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TRAFFIC VOLUME SUMMARY CITY _____DATE ____DAY ____ INTERSECTION OF _____AND____ TIME: _____TO ___ STREET NAME STREET NAME

Team No. Recorder

Dept. of Civil Engineering Kansas State University Manhattan, Kansas 66506

subject

LAB EXERCISES IN TRAFFIC ENGINEERING

title

SPEED STUDIES - PROBLEM STATEMENTS

Attached is a series of work problems on speed studies. These problems are to be worked for details required in their statements. Procedures and other necessary information to be used in the solution of these problems may be studied in the following references:

- "Traffic Engineering Theory and Practice," by Louis J. Pignataro -Chapter 8.
- "Fundamentals of Traffic Engineering," by Kennedy, Kell and Homburger - Chapter 5.
- 3. "Manual of Traffic Engineering Studies," by ITE Chapter 3.
- 4. Paper on "Space Mean Speed Versus Time Mean Speed," by Satish Mohan.

Spot-speed survey conducted with a radar meter on Anderson Avenue, between 1:15 P.M. and 1:30 P.M., on January 7, 1975, gave the following speeds of vehicles:

25	22	25	16	31	25	23
24	20	29	19	25	26 .	24
33	25	30	18	24	27	25
15	27	31	20	27	28	19
28	27	30	17	25	18	29
25	28	15	23	26	20	22
26	27	18	21	22	21	25
27	21	19	20	22	27	24
26	27	27	24	24	28	32
23	21	35	23	25	29	24
26	24	23	24	24	25	24
24	30	23	22	21	26	37
17	25	17	27	17	20	27
28	26	33	23	23	22	30
26	26	31	25	22	19	26
30	24	23	24	22	21	24
27	32	20	22	23	. 30	
25	22	19	20	24	29	
25	34	18	20	19	25	
24	23	20	22	18	25	

- 1. Group the field data and calculate the following:
 - (a) Average speed
 - (b) 85th percentile speed
 - (c) 15th percentile speed
 - (d) 50th percentile speed
 - (e) Mode and median speeds
- 2. Draw a cumulative speed curve and read (c), (d) and (e) above.

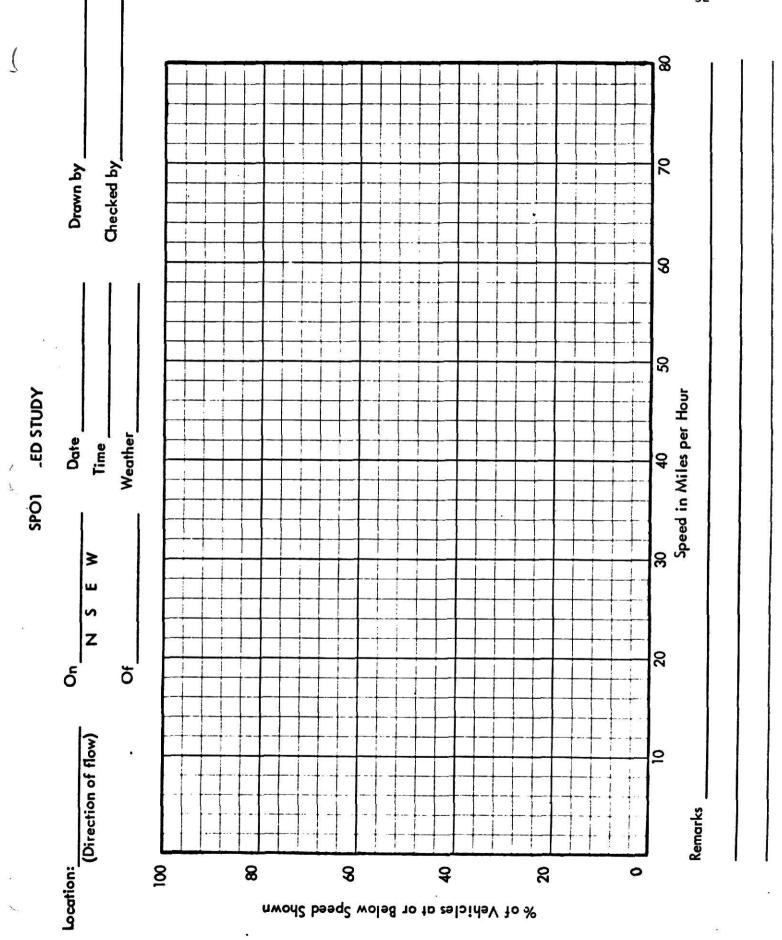


Fig. II-1

For the data given in problem 1, compute the following values:

- 1. The standard deviation.
- 2. The percent of vehicles in the pace, which is that 10 mph. range of vehicles which includes the most vehicles.
- 3. Standard error of the means.
- (b) What would you recommend as a speed limit on this facility? Explain your reasoning.

Test the observed speed values for fit to normal distribution, using the Chi-square test.

- (b) If the data fits the normal distribution, plot the curve and show mean, median and mode therein.
 - (ii) Also show P_{85} and P_{15} on the curve.
 - (iii) Compute the pace value from the normal curve.

A 20 mph. speed limit sign was installed on Anderson Avenue, and spot speed survey was repeated in February 1975. Analysis of this sample data gave the following information:

Mean speed = 22.5 mph.

Variance = 4.0

Sample size = 150

- (a) Did the posted speed limit cause the average speeds to change?
- (b) If a standard error of not more than 0.5 mph. is desired, is the sample size of 150, adequate?

Use "before data" from Problem 1.

Test runs made on a section of highway gave the following measurements:

Run	Overall Travel-time (Min.)	Overall Travel Speed (mph.)
1	3.0	60
2	3.6	50
3	4.5	40
4	6.0	30

- Calculate: 1) Time mean speed
 - 2) Space mean speed
 - 3) Average travel time

Speed studies made on a road in United Kingdom gave the following data:

Speed Range (mph.)	Volume (vph.)
2-5	1
6-9	4
10-13	0
14-17	7
18-21	20
22-25	44
26-29	80
30-33	82
34-37	79
38-41	49
42-45	36
46-49	26
50-53	9
54-57	10
58-61	3

Calculate: 1) Time mean speed

2) Space mean speed

Dept. of Civil Engineering Kansas State University Manhattan, Kansas 66506

subject

LAB EXERCISES IN TRAFFIC ENGINEERING

title

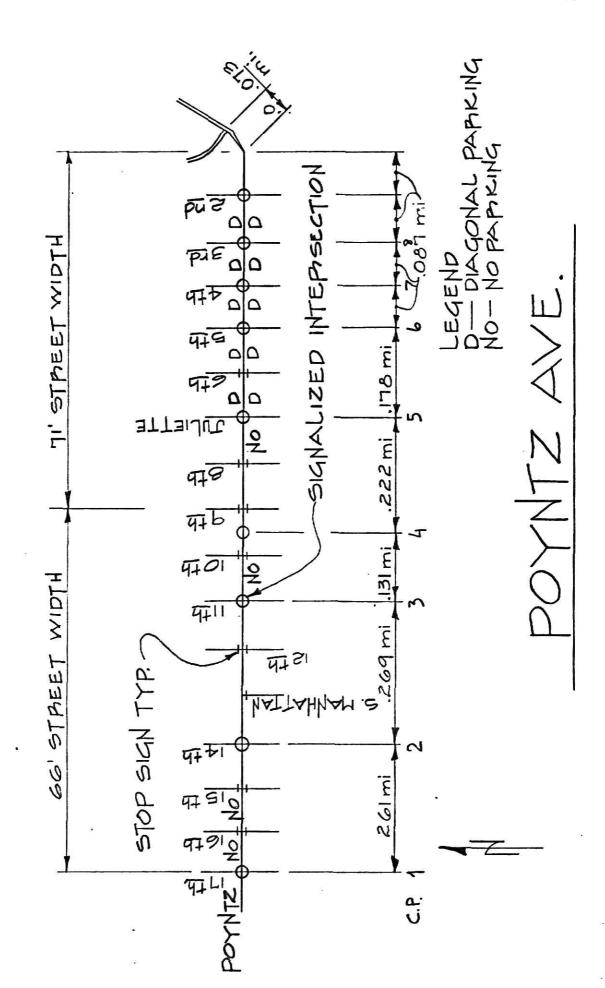
TRAVEL TIME AND DELAY STUDIES - PROBLEM STATEMENT

Attached are two problems on travel-time and delay studies. These problems may be solved as required therein. Procedures and other necessary information to be used in the solution of these problems may be studied in the following references:

- "Determining Travel Time," Procedure Manual 3B, National Committee on Urban Transportation.
- "Manual of Traffic Engineering Studies," Institute of Traffic Engineers - Chapter 3, pp. 37-44.
- "Traffic Engineering Theory and Practice," by L. J. Pignataro Chapter 7.
- "Fundamentals of Traffic Engineering," by Kennedy, Kell and Homburger -Chapter 6.

Nine test runs were made on Poyntz Avenue in the afternoon of January 8, 1975. Observations recorded for EB runs are enclosed. You are required to check these 9 runs for dispersion and choose the best 6 runs so as to stand the dispersion check. The data for these 6 runs may be analyzed to calculate the following, for each section between two control points. The test runs were made by three teams.

- 1) Travel time
- 2) Overall travel speed
- 3) Rate of motion
- 4) Delay rate. Standard rate of motion on Poyntz Avenue an arterial street may be taken as 2.40 min/mile.
- 5) Vehicle delay rate. Vol. on each section may be assumed as 1000 vph, in the direction of travel.



Grow # 9

TEST RUN #

ROUTE POYNTZ AVE. BETWEEN 17th Street AND 3rd Street DIRECTION EB DAY Wednesday DATE 1/8/75 BEGIN TIME 2:11(-DRIVER Mc Callum OBSERVER Stalfus WEATHER Four Wet

Inside Lame

	80			L	
СР	DESCRIPTION	ACCUM. TIME (MIN)	DELAY TIME (MIN)	DELAY* CODE	COMMENTS
1	17th	. 0' 0"			
2	14th	0'28"			Grein
3	11 12	1 20"	" דס	S	
4	Mid Block	1' 40"			S
5	T-nliet	2' 25"	13 "	S	
6	5 th	3'03"	6.5"	\$.	
7	4 15	3' 20"	2.5"	R	
8	3 ml	3' 49"	9"	S	
					THE RESERVE OF THE PROPERTY OF

*DELAY CODES: S - Traffic Signal

R - Vehicle Turning Right L - Vehicle Turning Left

C - Congestion

P - Vehicle Parking or Unparking Z - Other (Explain in COMMENTS)

Growh # 9
TEST RUN # 3

ROUTE POYNTZ AVE. BETWEEN 17th Street AND 3rd Street

DIRECTION EB DAY Wednesday DATE 1/9/75 BEGIN TIME 2:30

DRIVER Mc Callon OBSERVER Culmell WEATHER Fair Wet

Strifts

Courb Lance

					THE LIVE
СР	DESCRIPTION	ACCUM. TIME (MIN)	DELAY TIME (MIN)	DELAY*	COMMENTS
1	17 ts	o'- o''			
2	14 th	e'-34"			
3	ll ip	l'-2c"	10 "	S	[2]
4	Mid Block	(['] - 44"			
5	Filiet	2'-50"	27.5 "	\$	
6	5 th	3'-49"	28.5	S	
7	43	4'-16"	9"	Р	_
8	3	4"-sc"	6''	Р	

*DELAY CODES:

S - Traffic Signal

R - Vehicle Turning Right
L - Vehicle Turning Left

C - Congestion

P - Vehicle Parking or Unparking Z - Other (Explain in COMMENTS)

TEST RUN # 5

ROUTE POYNTZ AVE. BETWEEN 17th Street AND 3rd Street DIRECTION ER DAY Wednesday DATE 1/9/75 BEGIN TIME 2:45 DRIVER Mc Callium OBSERVER Conhact WEATHER Four Wet

1 17th 0'0" 2 14th 0'-31" 3 11th 1'-01" 4 11-id Block 1-15" 5 Juliet 1'-42" 6 5th 2'-07" 7 4th 2'-24"	CP	DESCRIPTION	ACCUM. TIME (MIN)	DELAY TIME (MIN)	DELAY* CODE	COMMENTS
3 11 th 1'-01" 4 11-id Block 1-15" 5 J-nliet 1'-42" 6 5th 2'-07"	1	17 th	ο' ο "			
4 1/mid Block 1-15" 5 J-nliet 1'-42" 6 5th 2'-07"	2	14 th	0'-31"			
5 Juliet 1'-42" 5 5th 2'-07"	3	11 15	'- 0 "			
6 5 th 2'-07"	4	Hid Black	1 -15"			
2-0/	5	Inliet	1'-42"			
7 4th 7'-74"	6	5 th	2'-07"			
	7	占ち	2'-24"			
8 3rd 3'-13" 34" S-L	8	3rd	3'-13"	34"	S-L	

*DELAY CODES: S - Traffic Signal

R - Vehicle Turning Right
L - Vehicle Turning Left
C - Congestion
P - Vehicle Parking or Unparking
Z - Other (Explain in COMMENTS)

Grown Ħ

TEST RUN #

ROUTE POYNTZ AVE. BETWEEN 17th Street AND 3rd Street DIRECTION EB BEGIN TIME 2:19 DAY Wednesday DATE 1/9/75 DRIVER Yearnat OBSERVER Walliams WEATHER Four Wet

СР	DESCRIPTION	ACCUM. TIME (MIN)	DELAY TIME (MIN)	DELAY* CODE	COMMENTS
1	175	0 0"			
2	14 th	o'- 43"			
3	11 15	1'-21"	5.1"	S	8
4	Mid Block	1' - 43"			
5	Inliet	2'- 27"	13,6"	S-L	
6	5 h	3'- 20"	23.2"	S-1	
7	4 15	3'-37"			(100 page
8	3rd	4'-15"	18.1"	S	

*DELAY CODES:

S - Traffic Signal
R - Vehicle Turning Right
L - Vehicle Turning Left
C - Congestion

P - Vehicle Parking or Unparking Z - Other (Explain in COMMENTS)

Great # 11

TEST RUN # 3

ROUTE POYNTZ AVE. BETWEEN 17th Street AND 3rd Street DIRECTION EB DAY Wednesday DATE 1/9/75 BEGIN TIME 2:34 DRIVER Trank OBSERVER M.T. WEATHER Four Wet

DESCRIPTION	ACCUM. TIME (MIN)	DELAY TIME (MIN)	DELAY* CODE	COMMENTS
ا 7 أ ^م	O O.,			
143	0'-36"			
U 55	1'-24"	11 "	S	
Mid Block	1'- 50"			
Fulriet	3'-1"	26.4"	\$	
15 ts	3'-36"	٠		
4 15	41-25"	27.4"	S	
374	5'-9"	24.8"	S	
	17 7 14 18 11 15 14 d. Block Fuliet 5 15 4 16	(MIN) 17	(MIN) (MIN) 17	(MIN) (MIN) CODE 17

*DELAY CODES: S - Traffic Signal
R - Vehicle Turning Right
L - Vehicle Turning Left

C - Congestion
P - Vehicle Parking or Unparking
Z - Other (Explain in COMMENTS)

46 Grant # 11 (i)

TEST RUN # 5

ROUTE POYNTZ AVE. BETWEEN 17th Street AND 3rd Street DIRECTION E 123 DAY Wednesday DATE 1/8/75 BEGIN TIME 2:45 OBSERVER ___ C.C. WEATHER Four Wet DRIVER TENTONE

CP	DESCRIPTION	ACCUM. TIME (MIN)	DELAY TIME (MIN)	DELAY*	COMMENTS
1	17 13	0'-0"			
2	14 15	0'-36"			
3	11 15	1'-12"			
4	Mid Block	1'-31"			
5	Inh et	2'-05"			
· 6	5 ^{lħ}	3'-05"	23.5"	Š	
7	4 15	3' - 37"	10 "	Р	
8	3rd	4'-25"	29.9"	S	

*DELAY CODES:

S - Traffic Signal
R - Vehicle Turning Right
L - Vehicle Turning Left

C - Congestion
P - Vehicle Parking or Unparking
Z - Other (Explain in COMMENTS)

Cornh # 10 TEST RUN # _ !

ROUTE POYNTZ AVE. BETWEEN 17th Street AND 3rd Street DIRECTION EB DAY Wednesday DATE 1/9/75 BEGIN TIME 2:05 DRIVER Garner OBSERVER Colman WEATHER Four Wet

СР	DESCRIPTION	ACCUM. TIME (MIN)	DELAY TIME (MIN)	DELAY* CODE	COMMENTS
1	17 th	C'- C''			
2	14 15	0' - 35"	4 "		
3	II its	1 - 13"			
4	Mid Block	1-29"	27"	S	
5	Inhet.	2'-3c"	14"	L	
6	5 lh	3'-15"	51"	P+L+C	
7	4 15	4'-16"	24"	C-P	
8	3.rd	5'-4"			

*DELAY CODES: S - Traffic Signal

R - Vehicle Turning Right L - Vehicle Turning Left

C - Congestion
P - Vehicle Parking or Unparking
Z - Other (Explain in COMMENTS)

Grank # 10

TEST RUN #

ROUTE POYNTZ AVE. BETWEEN 17th Street AND 3rd Street DAY Wednesday DATE 1/9/75 BEGIN TIME 2:35 Tredmore WEATHER Four Wet DRIVER CHANCE OBSERVER

DESCRIPTION	ACCUM. TIME (MIN)	DELAY TIME (MIN)	DELAY*	COMMENTS
۱7 ^{'۴}	p' - o"			
14 16	0'-31"			
II '5	l' - 00"			
Meil Block	1'- 15"	36.4	L-S	
John L	2'-17"	18.5	5	
5 ¹ 5	3'-5"	6,5	S	
Ц ¹ Ъ	3'-30"	29,2	L-S	
3 rd.	4'-18"			
	17 h 14 h 11 h 11 h Mil Block Johich 5 h 4 h	(MIN) 17 'B 0'-0" 14 'B 0'-31" 11 'B 1'-00" Mil Block 1'-15" Tolich 2'-17" 5 'B 3'-5" 4 'B 3'-30"	(MIN) (MIN) 17 '5 0' - 0" 14 '6 0' - 31" 11 '5 1' - 00" Mil Block 1' - 15" 36.4 Tolich 2' - 17" 18.5 5 '6 3' - 5" 6.5 4 '6 3' - 30" 29.2	(MIN) (MIN) CODE 17 'h 0'-0" 14 'h 0'-31" 11 'h 1'-00" Mil Blink 1'-15" 36.4 L-S Thich 2'-17" 18.5 S 5 'h 3'-5" 6.5 S 4 'h 3'-30" 29.2 L-S

*DELAY CODES: S - Traffic Signal

R - Vehicle Turning Right L - Vehicle Turning Left

C - Congestion

P - Vehicle Parking or Unparking Z - Other (Explain in COMMENTS)

Grank # 10

TEST RUN # 5

D 3rd Street

ROUTE POYNTZ AVE. BETWEEN 17th Street AND 3rd Street

DIRECTION EP DAY Wednesday DATE 1/8/75 BEGIN TIME

DRIVER Garner OBSERVER Saint Molan WEATHER Four Wet

СР	DESCRIPTION	ACCUM. TIME (MIN)	DELAY TIME (MIN)	DELAY*	COMMENTS
1	17 it	0'-0"			
2	14 1h	0'-50"	17"	S	
3	11 ¹⁶	1-25"			
4	Mul Block	1'-43"			
5	Fuliet.	2'-17"			
6	5 [/] 4	3'-2"	15"	5	
7	4 1h	3'-33"	12."	C -	- Mid Block
8	370C	4'-7"	23"	S	

*DELAY CODES:

S - Traffic Signal

R - Vehicle Turning Right L - Vehicle Turning Left

C - Congestion

P - Vehicle Parking or Unparking Z - Other (Explain in COMMENTS)

It is gathered that a passenger car took 12 minutes to travel a 6 mile long section AB of a major arterial, at a speed of 30 mph, in 1960 when there were no intersections between A and B. Later is 1970, it was considered necessary to provide an at grade signalized intersection at C, midway between A and B. A recent delay study made on this section, in a passenger car travelling at 30 mph. from A to B gave the following observations.

The driver noticed the signal while he was 600 ft. away from C, reduced his speed and after stopping for 20 seconds at C, accelerated so as to be travelling at 30 mph. at 500 ft. from C. Total travel from A to B took 13 minutes. Calculate the following for this travel.

- 1) Stopped time delay
- 2) Travel-time delay
- 3) Fixed delay
- 4) Running speed
- 5) Overall travel speed

Dept. of Civil Engineering Kansas State University Manhattan, Kansas 66506

title INTERSECTION DELAY STUDIES - PROBLEM STATEMENT

Attached is a problem on intersection delay study by Calculator Method.

The field data may be analyzed to calculate the various delays required in the problem. The procedure and other relevant guidance to be used in the solution of this problem may be studied in the following references:

- "Traffic Engineering Theory and Practice," by L. J. Pignataro -Chapter 7 (pp-111)
- "A Comparison of Three Methods for Measuring Delay at Intersections," by Berry and Van Til, TE, December 1954.

Calculator method was used to evaluate the operation of an intersection. A 30-second sample of field data is enclosed on the sample recording form. Analyze the data to calculate the following:

- 1) Percent of vehicles delayed.
- 2) Average seconds of delay per vehicle.
- 3) Average seconds of delay per delayed vehicle.
- 4) Total vehicle seconds of delay for the intersection.

INTERSECTION DELAY -CALCULATOR METHOD

.CATION: ON		AT	
APPROACH: N, S,	Е, И.		
DATE:	; WEATHER:	RECORDER:	
CALCULATOR SPEED	: BECIN: 246/30 sec.	END: 248/30 sec.	
K = 494 TPS	8.233 Rev/Sec.		

1				<u>'</u>			
TIME ENDING	FIELD DATA			· ANALYSIS DATA			
	Calculator Read(VchSec/k)	Vehicles Delayed	Vehicles Thru	Total Vol.	Total delay	Delay per Delay veh.	Delay per veh
	1	2	3	4=2+3	5=1/k	5/2	5/4
0910	884	8	5				
0912	2295	15	5 ·				
0914	4177	19	-5				
0916	1535	14	2			-	
0918	984	10	4 :				
0920	653	. 7	8 ·				
0922	246	11	66				
0924	349	3	5				
0926	364	2					
ბ928	1004	8	-1				
0930	360	6	2				
0932	250	11	66				
0934	. 988	8	6				
0936	265	4	3				
0938	64	2	1				
0940	377 .	3	6		· · ·		

I-3.5 DELAY MEASUREMENT

3.5.1 INTERSECTION DELAY - CALCULATOR METHOD

1. THE EVALUATION OF THE OPERATION OF AN INDIVIDUAL INTERSECTION AND ITS APPROACHES CAN BE MADE BY A MEASUREMENT OF THE DELAY TIME OF THE VEHICLES. METHODS INCLUDE MANUAL TIMING OF VEHICLES OR SAMPLES, MEASURING THE AVERAGE DELAY TIME OF A PLATOON, ETC. THE CALCULATOR METHOD WAS DEVELOPED BY ITTE IN THE EARLY 1950'S AND HAS BEEN FOUND TO BE AN EFFECTIVE RESEARCH AND OPERATIONAL TECHNIQUE. THE TYPE OF CALCULATOR USED IS THE TYPE IN WHICH THE UPPER BANK ROTATES AT A MULTIPLE SPEED OF THE LOWER BANK, DEPENDING UPON WHICH KEY IS DEPRESSED. OLDER MODELS FRIDEN AND MONROE USUALLY WORK.

A. GENERAL DESCRIPTION:

THIS TYPE OF STUDY HAS BEEN FOUND EFFECTIVE IN EVALUATING THE AMOUNT OF DELAY EXPERIENCED BY VEHICLES ENTERING AN INTERSECTION UNDER ANY TYPE OF TRAFFIC CONTROL. THE RESULTS GENERALLY REPORTED AS: a) NUMBER OR PERCENTAGE OF VEHICLES DELAYED; b) AVERAGE SECONDS OF DELAY FLR VEHICLE; c) AVERAGE SECONDS OF DELAY PER DELAYED VEHICLE; AND d) TOTAL VEHICLE SECONDS OF DELAY PER APPROACH OR FOR THE INTERSECTION.

B. PROCEDURE:

- LOCATE A POWER SOURCE, I.E., TRAFFIC SIGNAL CONTROLLER OR SERVICE STATION.
- 2. SELECT A LOCATION TO VIEW THE APPROACH BEING STUDIED FOR AS LONG A DISTANCE AS TRAFFIC NORMALLY BACKS UP.
- 3. USE A CONSTANTLY RUNNING ELECTRIC CALCULATOR WITH A DUAL BANK SUCH THAT ONE BANK RUNS AT A CONSTANT SPEED WHILE THE OTHER INCREASES AS THE KEYBOARD DIGIT KEY INCREASES (FRIDEN, MONROE).
- 4. DEPRESS THE PLUS BAR (ALSO THE 1-KEY ON SOME MACHINES) AND RUN A 60-SECOND CALIBRATION TEST TO OBTAIN THE MACHINE'S SPEED OF ROTA-TION. RECORD DATE.
- 5. DEFINE THE TERM DELAY FOR THE PARTICULAR DELAY, I.E., STOPPED, ROLLING, LESS THAN 5 MPH. ETC.
- 6. USE A CLIPBOARD WITH STOPWATCH, RECORDING FORM AND VOLUME COUNTERS
- 7. FOR SIGNALIZED INTERSECTION CONTROL. AS THE FIRST VEHICLE APPROACHES THE RED LIGHT, THE 1-KEY AND PLUS BAR ARE DEPRESSED. AS THE SECOND CAR STOPS BEHIND THE FIRST, MOVE THE FINGER FROM THE 1-KEY TO 2; AND SO FORTH UNTIL THE SIGNAL CHANGES TO GREEN. THEN REVERSE THE PROCEDURE AS VEHICLES ENTER THE INTERSECTION BUT KEEPING A BALANCE WITH ADDITIONAL CARS ACCUMULATING AT THE END OF THE QUEUE.
- 8. WHEN ALL VEHICLES ARE MOVING ON THE GREEN, DEPRESS THE VOLUME COUNTER TO RECORD THE NUMBER OF VEHICLES IN THE QUEUE (DO NOT INCLUDE THOSE ENTERING LATER AS THEY ARE NORMALLY COUNTED IN THE NEXT CYCLE).
- 9. ON ANOTHER VOLUME COUNTER, RECORD THE CARS THROUGH THE INTERSECTION.
 ON GREEN (NO DELAY).

- 10. THE SUM OF THE TWO COUNTS REPRESENTS THE TOTAL VOLUME ON THE APPROACH.
- 11. PERIODICALLY (PER CYCLE, 5 MIN., 15 MIN., HOUR) RECORD THE VOI ME AND CALCULATOR VALUES AND CLEAR TO START OVER.
- 12. SEE SAMPLE RECORDING FORM.
- 13. AT THE END OF THE STUDY RUN ANOTHER 60-SECOND CALIBRATION TEST

INTERSECTION DELAY -CALCULATOR METHOD

			*	•			12
.CATI	ON: ON						
APPROA	CH: N, S, E, W.						
DATE:_	· ;	WEATHER:_	· · · · · · · · · · · · · · · · · · ·		RECORD	ER:	
CALCUL	ATOR SPEED: BECI	٧:	; ENC);	•		
K =	rps				•		
•				•			
TIME ENDING	FIELD DA	AT.			ANALYSI	S DATA	
	Calculator	Vehicles		Total	Total	Delay per	Delay
	Read (VchSec/k)	Delayed	Thru	Vol.	delay	Delay veh.	per vel
	1	2	3	4=2+3	5=1/k	5/2	5/4
		-					
			:				
 							
							
			· ·				
•						-	
							,,,,,,,
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subject

LAB EXERCISES IN TRAFFIC ENGINEERING

title

INTERSECTION SIGHT DISTANCES - PROBLEM STATEMENT

Attached is a problem on intersection sight distances. You are required to work out the solutions of points made in the problem. Procedures and other relevant information to be used in the solution of the problem may be studied in the following references:

- "Traffic Engineering Theory and Practice," by L. J. Pignataro -Chapter 25.
- "Fundamentals of Traffic Engineering," by Kennedy, Kell and Homburger - Chapter 20.
- 3. "A Policy on Geometric Design of Rural Highways AASHO, pp. 392-406.
- 4. "Intersection Sight Distances," Stock No. 3516, Northwestern University Enclosed.

Detailed study of an uncontrolled intersection with a high accident rate has revealed that inadequate sight distances for the approaching vehicles are the sole cause of vehicle conflicts. The City Engineer, in a bid to arrive at the best solution of the problem, is considering the following possible alternatives:

- 1) To shift the structure back.
- 2) Reduce speed limits on both approaches.
- 3) Reduce speed limit on minor approach only.
- 4) Provide the least restrictive control.

Calculate safe stopping distances for the two approaches, draw a sight triangle, and determine the following:

- 1) Is it safe for vehicles to approach the intersection, at their respective speed limits?
- 2) If not, what speed is safe for vehicle on Approach A if vehicle on major approach B is operating at the speed limit?
- 3) If speed limit on major Approach B is brought down to 25 mph, what will be safe approach speed on A?
- 4) How far back the structure must be shifted to make any speed reductions unnecessary?
- 5) If intersection control is proposed, which device will you select to provide for the necessary regulation of right-of-way?

Given:

Speed limit on approach, $V_A = 20 \text{ mph.}$, $V_B = 30 \text{ mph.}$

Reaction time t = 1.5 sec.

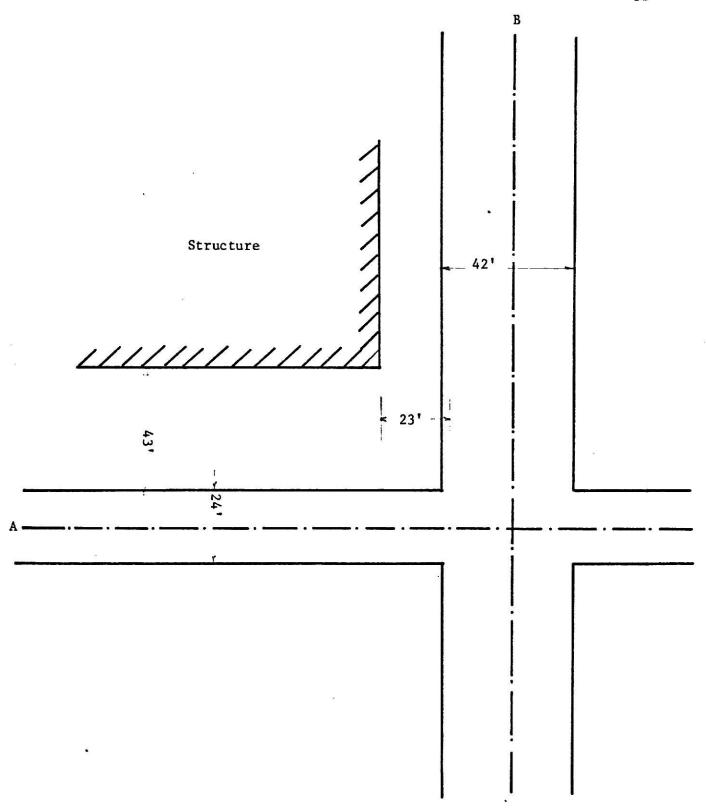
Friction factor f = 0.50

Grade on approach, $g_A = 0\%$, $g_B = 5\%$

Constant clearance $C_D = 15 \text{ ft.}$

6) Select an intersection and determine the safe approach speed(s) using the sight angle board technique and the attached reference material.





Scale: 1" = 32'

Fig. V-1



subject

TRAFFIC ENGINEERING CONTROL

title

INTERSECTION SIGHT DISTANCES (SAFE APPROACH SPEEDS)

Introduction

A. Sight Distance

There are potential vehicle conflicts at every intersection. The possibility of these conflicts actually occurring can be greatly reduced through proper channelization and appropriate traffic controls, but the avoidance of accidents and the efficiency of traffic operation must still depend to a large extent upon the judgment, capabilities and responses of the individual driver. The intersection design must provide sufficient sight distances for the driver to perceive potential conflicts and to carry out the actions needed to negotiate the intersection in safety.

II. Safe Approach Speed at Intersections

Drivers approaching an uncontrolled intersection should have an unobstructed view great enough to enable them, after perceiving a vehicle on the cross road, to decide whether to stop, change speed, or continue through the intersection. The greatest distance is required when it is necessary to decide whether or not to stop.

A. Figure 1 shows the sight triangle which is developed when two vehicles approach the same intersection. The stopping sight distance SSD is given by:

SSD = Reaction Distance + Braking Distance + Clearance Distance (1)

SSD = 1.47V(t) +
$$\frac{V^2}{30(f+g)}$$
 + C_D (2)

where:

V = Speed of vehicle (assumed 85th P or speed limit)

t = Reaction time (1/2 - 1 1/2 seconds)

f = Friction factor

g = Grade on the approach

 C_{D} = Constant Clearance Distance = 15 feet

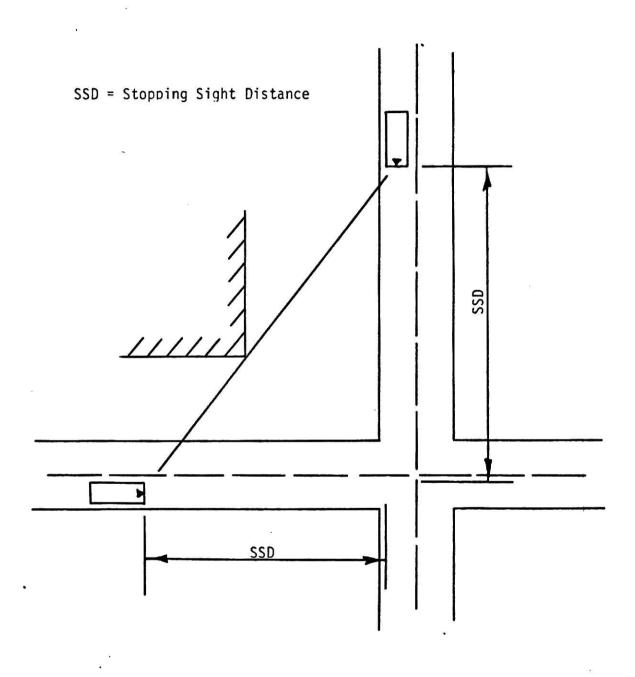


FIGURE 1

B. For example, assume the following intersection geometrics and speed data.

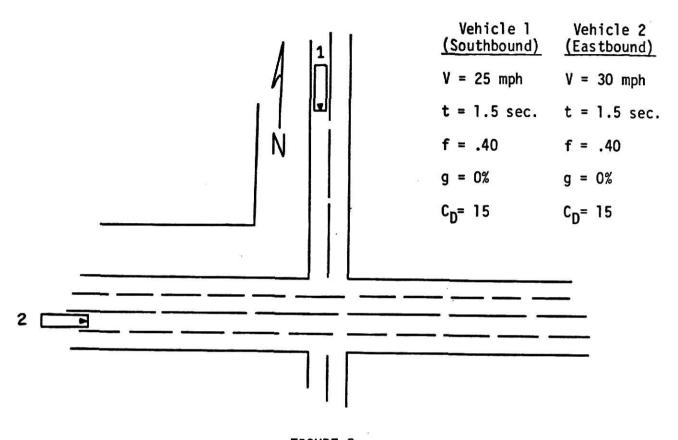
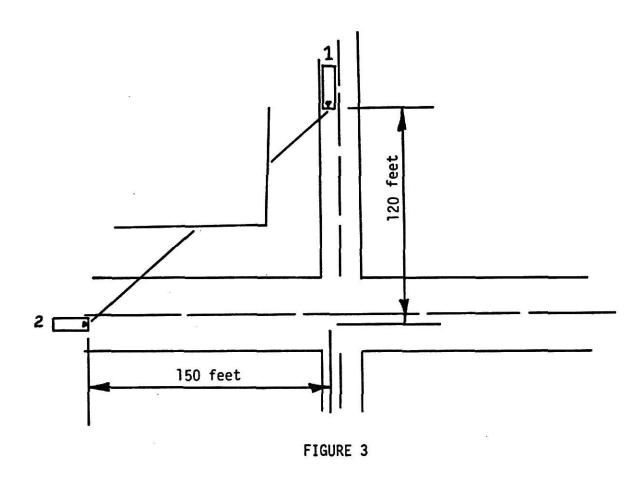


FIGURE 2

Calculating SSD for both vehicles:

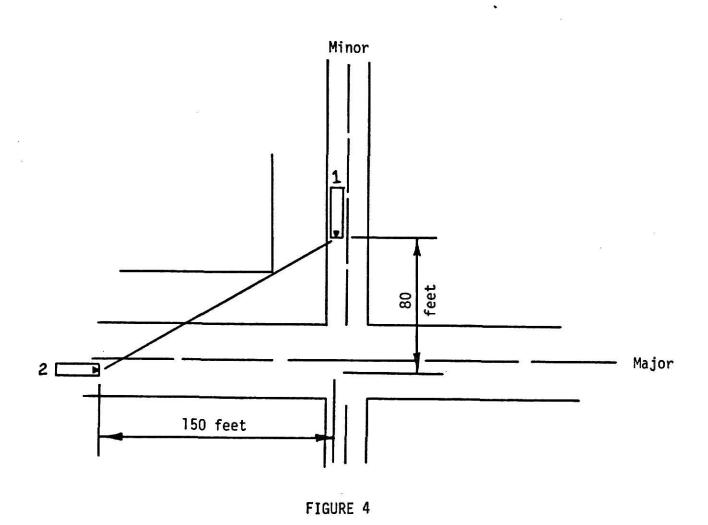
$$SSD_1 = 1.47(25)(1.5) + \frac{25^2}{30(.4)} + 15 = 122 \text{ feet (Call it 120 feet)}$$

$$SSD_2 = 1.47(30)(1.5) + \frac{30^2}{30(.4)} + 15 = 156$$
 feet (Call it 150 feet)



C. After constructing the sight triangle on the above scale drawing it can be seen that the obstacle in the northwest quadrant blocks the view of the approaching vehicles. In other words, it is not safe for those vehicles to approach the intersection at the respective speed limits.

- D. The next question, which has more application to intersection studies, is just what speed is it safe for vehicle 1 to approach the intersection if vehicle 2, the vehicle on the major road, is operating at the speed limit?
- E. Figure 4 gives the graphical explanation of this problem.



- 1. From the above scale drawing, vehicle 1 will not see vehicle 2 until 80 feet or less from the intersection.
- Using 80 feet, solve for the speed of vehicle 1 which will give that vehicle enough time to stop, change speed or continue through the intersection.

$$V = ?$$

$$t = 1.5 \text{ sec.}$$

$$f = .40$$

$$q = 0%$$

SSD = 1.47V(t) +
$$\frac{V^2}{30(f)}$$
 + 15

$$80 = 1.47(V)(1.5) + \frac{V^2}{30(.4)} + 15$$

$$V = 18 \text{ mph}$$

- 3. This means that the <u>Safe Approach Speed</u> for minor street is 18 mph. More positive control is necessary if vehicles approach the intersection at a speed greater than 18 mph.
- F. Safe Approach Speed studies are applicable to the following problems.
 - Determining if there is a view obstruction at the prevailing speeds.
 - Finding out how far back a view obstruction must be removed to make further speed reductions unnecessary.
 - Determining what restriction of parking is required to "open up" the intersection.
 - 4. Deciding whether there is a sufficient view obstruction to require a stop sign.
 - 5. Determining whether a yield sign is desirable.
 - 6. Establishing design standards and zoning ordinances which will eliminate view obstructions on new or improved streets or highways.

III. Safe Approach Speed Check (Simplified Field Method Using Sight Angles)

A. There is a simpler method to determine safe approach speed for intersections. This involves measuring or determining the sight angles or sight distances on all corners of the intersections.

The figure below shows the typical situation.

x = 6 ft.

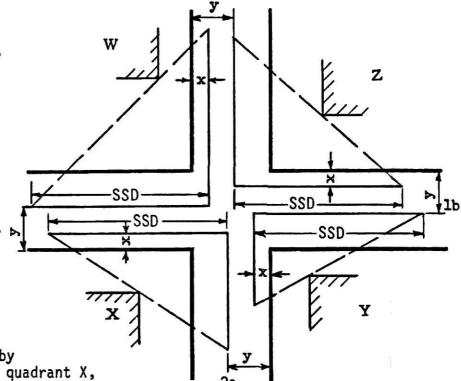
y-1/2 street width + 3 ft. (two-way)

y = street width - 4 ft. (one-way street)

SSD = 70 ft. (20MPH limit)

ssn - 90 ft. (25 MPH limit)

SED = 120 ft. (30 MPH limit)



Procedure:

 Assume (la) approach speed same as speed limit.

 Establish collision point by measurement of x and y for quadrant X, and mark.

3. Measure distance SSD for assumed speed, along approach line (la) (x distance from the curb), and mark point.

4. Set up sight angle board, facing toward collision point and with zero angle line along approach line (la).

Sight maximum angle as limited by obstruction X.

6. Classify speed range from following table. This is the maximum safe speed for approach (2a) when (1a) is at speed limit. The reverse is also true (if (2a) approaches at speed limit, above value is maximum safe speed for (1a)).

7. Repeat angle measurement for quadrant W, using proper approach lines (y distance from curb (la) x distance from curb (2b)). Check table

for safe approach speed (2b).

8. Measure out distance SSD on approach (1b) and follow above steps for quadrants Y and Z.

	CLASS					
APPROACH SPEED LIMIT	I (Over 45°)	II (30° to 45°)	III (15° to 30°)	IV (Less than 15°)		
20 MPH	20 MPH & Over	13 to 19 MPH	5 to 12 MPH	0 to 4 MPH		
25 MPH	25 MPH & Over	16 to 24 MPH	6 to 15 MPH	D to 5 MPH		
30 MPH	30 MPH & Over	20 to 29 MPH	10 to 19 MPH	O to 9 MPH		

SIGHT ANGLE BOARD FOR MEASURING SAFE APPROACH SPEED (CONSTRUCTION DETAILS)

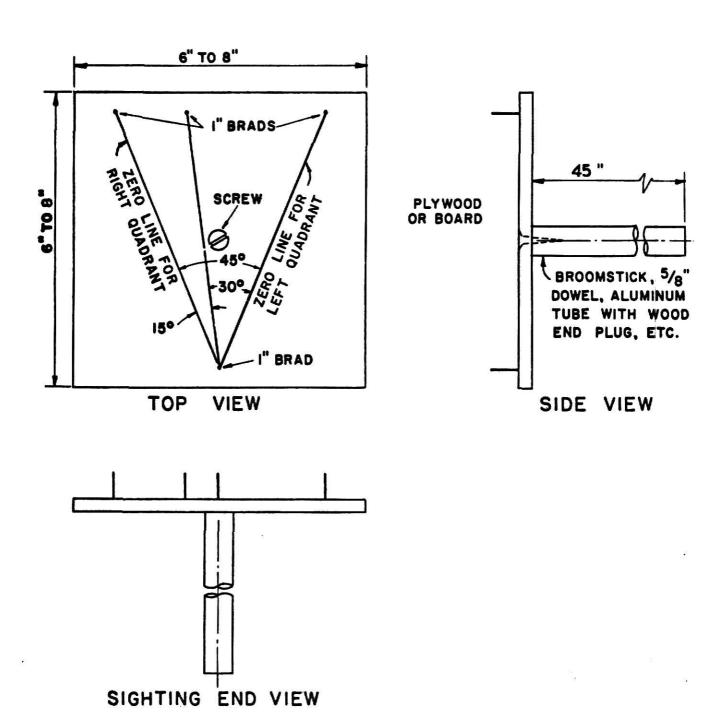


FIGURE 5a

*Remember - The Stopping Sight Distance (SSD) is given by:

SSD = Reaction Distance + Braking Distance + Clearance Distance

SSD = 1.47V(t) +
$$\frac{v^2}{30(f+g)}$$
 + C_D

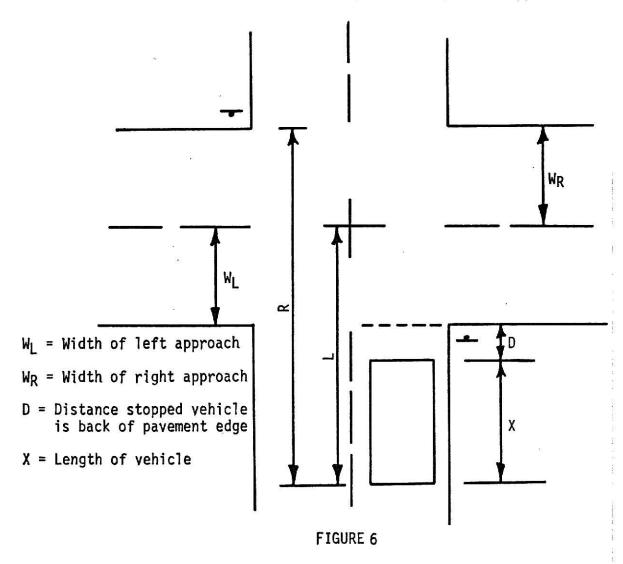
A number of factors affect the safe approach speed and therfore several assumptions have to be made: Approaching vehicles are in the most dangerous legal position in respect to lateral placement on the roadway; driver reaction time is I second (urban); coefficient of friction of the street is 0.5; and the clearance distance is 15 feet.

B. <u>Suggested Criteria Based on Safe Approach Speed</u>

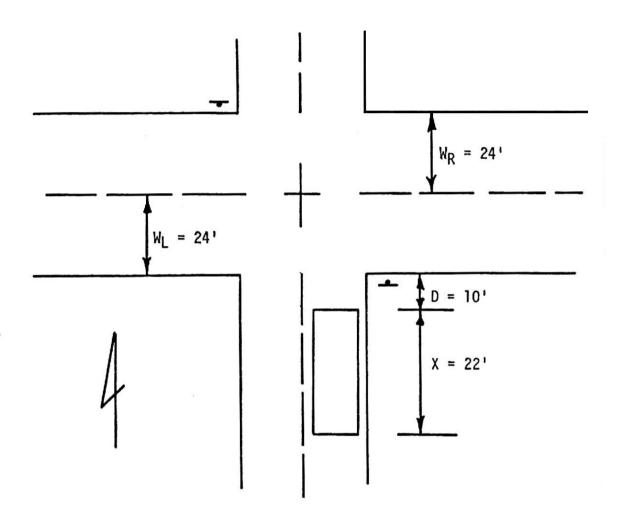
- 1. If a critical sight restriction exists:
 - First, determine if obstruction can be eliminated or modified.
 - b. Second, determine relationship of measured approach speed (85th percentile) to calculated safe speed.
 - c. Third, determine suitability of speed zone or advisory speed limit.
 - d. Fourth, if intersection control is indicated, select most appropriated device.
- 2. The type of control employed should be the least restrictive control that provides for the necessary regulation of right-of-way depending upon the critical approach speed determination.
 - a. Critical approach speed in range of 0 to 10 mph; consider 2-way or 4-way stop.
 - b. Critical approach speed greater than 10 mph but less than speed limit or 85 percentile speed; consider yield or 2-way stop.
 - c. Critical approach speed is equal to or greater than speed limit or 85 percentile speed; consider right-of-way rule or yield sign.

IV. Sight-Distance Requirements at Two-Way Stop Controlled Intersections

A. When a vehicle which is stopped at an intersection that has twoway Stop Control crosses the intersection and continues in the same direction, the stopped vehicle must move a distance L as shown in Figure 6 before clearing the approach on the left and a distance R before clearing the approach on the right. Once the vehicle has moved those distances it would no longer be in conflict with crossroad vehicles using those respective approaches.



B. In Figure 7, dimensions are given for a typical intersection and the clearance distances L and R are calculated.



$$L = X + D + W_L = 22 + 10 + 24 = 56'$$
 (1)

$$R = X + D + W_L + W_R = 22 + 10 + 24 + 24 = 80'$$
 (2)

FIGURE 7

C. Using a reasonable estimate of the acceleration rate of a passenger car it is possible to calculate the time in seconds it takes a vehicle to clear the left approach (distance L) and then the right approach (distance R). In practice the rate depends on both the aggressiveness of the driver and the acceleration capability of the passenger car but for safe design the engineers utilize the slower rate of a conservative driver in a typical passenger car. Without discussing the derivation of the formula, these times can be calculated as follows:

$$t_{R} = \sqrt{\frac{2R}{a}}$$
 (3)

$$t_{L} = \sqrt{\frac{2L}{a}}$$
 (4)

where:

a = acceleration rate of a passenger car = $4.5^{1}/\sec^{2}$

AND

 t_1 = the time to traverse the left approach

 t_p = the time to traverse the right approach

In our example, where R = 80' and L = 56':

$$t_{R} = \sqrt{\frac{2R}{a}}$$
 = $\sqrt{\frac{2(80)}{4.5}}$ = 6.0 sec ±
 $t_{L} = \sqrt{\frac{2L}{a}}$ = $\sqrt{\frac{2(56)}{4.5}}$ = 5.0 sec ±

This is the passenger car acceleration rate used in Figure VIII-4 on page 397 of A Policy on Geometric Design of Highways, 1965 published by the American Association of State Highway Officials.

D. The time to traverse the distances R & L is not the only consideration in determining how long it takes a vehicle to clear the respective approaches. The time that it takes to stop vehicle to clear the intersection is the time it takes to traverse the right approach or the left approach (t_R or t_L) plus a reaction time which allows the driver of the stopped vehicle to perceive adequate clearance and react accordingly. Putting this into a formula:

$$T_{R} = (t_{R} + J) \qquad (5)$$

$$T_{L} = (t_{R} + J) \qquad (6)$$

where:

 T_R = the total clearance time for the right approach T_L = the total clearance time for the left approach

In our example, the calculations would be as follows:

$$T_R = (t_R + J) = 6.0 + 1.0 = 7.0 \text{ seconds}$$

 $T_I = (t_L + J) = 5.0 + 1.0 = 6.0 \text{ seconds}$

The American Association of State Highway Officials recommends a reaction time for this situation of 1 second in urban areas and 2 seconds on rural areas on page 395 of A Policy on Geometric Design of Highways, 1965.

E. For safe operation, the length open to view to the right and to the left of the stopped driver must be greater than the distance the cross vehicles would travel during the time the previously stopped vehicle is clearing the respective approaches (T_R & T_L). The open distance requirement is referred to as sight distance. The formulas to calculate the distance these crossroad vehicles will move, and hence the sight distance requirement, is given by the following formulas:

$$SD_R = 1.47 \text{ V } (T_R)$$
 (7)

$$SD_L = 1.47 \ V \ (T_L)$$
 (8)

where:

V = speed limit on the crossroad

 SD_{R} = sight distance to the right

 SD_{l} = sight distance to the left

- F. These sight distances are measured using a height of eye of 3.75" and a height of object of 4.5'
- G. If the actual sight distance to the left and to the right at the intersection is less than those calculated using the above formulas, then it is unsafe for the vehicles on the crossroad to travel at the posted speed limit.

Using out example data and assuming that the speed limit is 35 mph on a crossroad:

$$SD_R = 1.47V(T_R) = 1.47(35)(7.0) = 360 \pm 50 = 1.47V(T_1) = 1.47(35)(6.0) = 310 \pm 50 = 1.47V(T_1) = 1.47(35)(6.0) = 310 \pm 50 = 1.47V(T_1) = 1.47(35)(6.0) = 310 \pm 1.47V(T_1) = 1.4$$

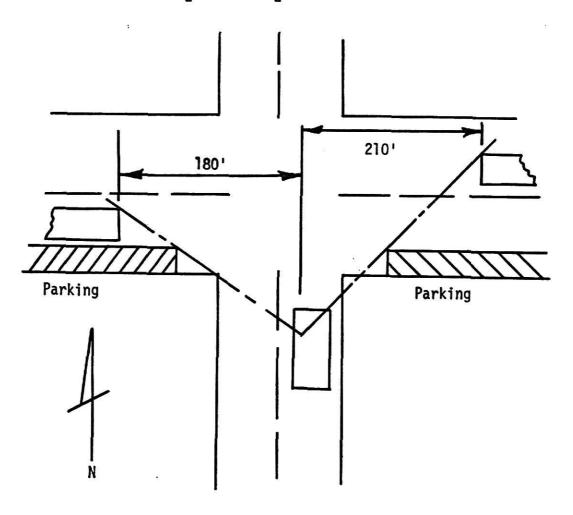
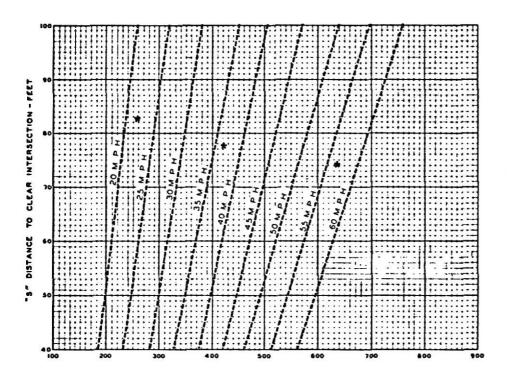


FIGURE 8

H. Assume, in our example, that parking is allowed along the south side of the crossroad as shown in Figure 8. If a vehicle is placed at the stop line, this parking condition allows only 210 feet of sight distance to the right and 180 feet of sight distance to the left. Comparing these physical conditions with the SD_R and SD_L previously calculated, it is obvious that this intersection is unsafe if vehicles on the crossroad are allowed to continue to travel at the existing speed limit.

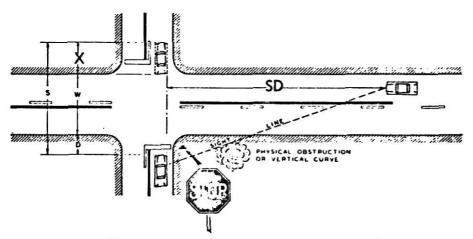
IV. Sight-Distance Requirements At Two-Way Controlled Intersections (Graphical)

A. Maximum Safe Approach Speed for Intersection Approach with Stop Control on Minor Road (Rural)²



*Speed in miles per hour for major route

SIGHT DISTANCE TO CONFLICT POINT - FEET



(For one direction of travel only) FIGURE 9

- (1) In urban or suburban areas the values for distance to conflict may be reduced about 13 percent.
- Check AASHO publication entitled A Policy on Geometric Design of Highways, 1965 for sight distances for trucks.

The sight line is from a point 3.75 feet above the road to a point 4.5 feet above the road.

S = Distance to clear intersection - feet

X = Length of car (20 feet)

W = Width of thru street - feet

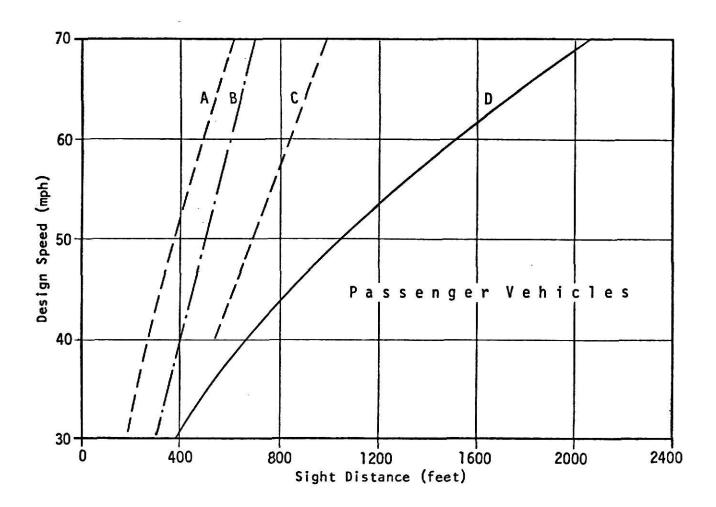
D = Distance from front of normal stop position to edge of thru street - feet

SD = Distance along thru street to conflict point

B. Additional Considerations

There are additional sight distance requirements for turning movements after a stop. Figure 10 indicates some of these requirements for passenger vehicles. Curve B is for a direct crossing. Curve C is for a left turn across the path of a vehicle approaching from the left and Curve D is for a left turn in which the turning vehicle is overtaken by a vehicle approaching from the right. The last Condition requires the longest sight distance. The requirement for a right turn would be somewhat less than for the left turn. Requirements for trucks making left or right turns would be substantially greater than for passenger vehicles.

Curve	Represents
A	Safe Stopping sight Distance
В	Safe Sight Distance for P vehicle, crossing 2-lane highway from stop.
С	Safe Sight Distance for P vehicle turning left into 2-lane highway across P vehicle approaching from left.
D	Safe Sight Distance for P vehicle to turn left into 2-lane highway and attain Average Running Speed before being overtaken by P vehicle approaching in same direction at Design Speed.



INTERSECTION SIGHT DISTANCE RELATIONS

Stop Control on Approach to 2-Lane Major Highway

FIGURE 10

Dept. of Civil Engineering Kansas State University Manhattan, Kansas 66506

subject

LAB EXERCISES IN TRAFFIC ENGINEERING

title

TRAFFIC SIGNAL SYSTEMS AND NETWORKS - PROBLEM STATEMENT

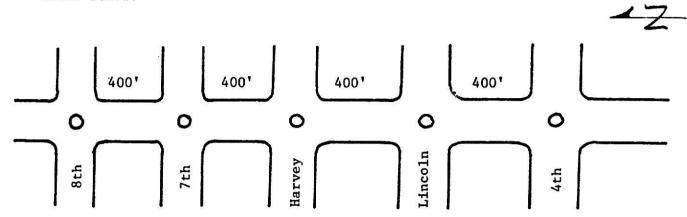
Attached are two problems on Traffic Signal Systems and Networks. These Problems are to be worked for details required in their statements.

Procedures and other necessary information to be used in the solution of these problems may be studied in the following references:

- "Traffic Engineering Theory and Practice," by Louis J. Pignataro - Chapter 24.
- "An Introduction to Highway Transportation Engineering" -Chapter 10.
- "Fundamentals of Traffic Engineering," by Kennedy, Kell and Homburger - Chapter 25.

PROBLEM 1

The spacing of traffic signals in Wellington, Kansas (CBD) are shown below:



400 ft. stop-line to stop-line distance
0 → represents signalized intersection

Fig. VI-1

All signals are fixed time with a cycle length of 50 seconds. The cycle splits are all 50-50 except the intersection at Washington and Harvey where a capacity analysis indicates that 60 percent of the green time be allocated to Washington Street (60-40, N-S, cycle split). The desired speed is 20 mph.

Using time-space diagrams, determine the following for each case indicated below for Washington Street. Only be concerned with N-S progression as volumes on east-west streets are minimal. An industrial park is located north and a residential area directly south of the CBD.

Determine: (a) The timing offsets using 8th Street as a reference.

- (b) The width in seconds of the green band for each direction.
- (c) The efficiency of the green band in each direction.
- (d) The maximum and minimum constant speeds that a driver could travel in each direction and not encounter a red signal.
- Case 1: Balanced two-way progression (i.e. Green bands of approximately equal width and speed in each direction).
- Case 2: All signals set to favor southbound (evening peak) traffic.

Progression	=	Ft/Sec.	MPH .
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PROBLEM 2

For the one-way street network shown below, the following data are given:

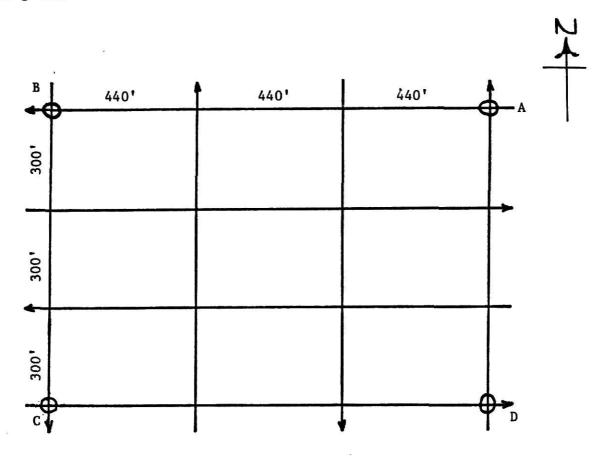


Fig. VI-2

Fixed time signals are located at A, B, C, D.

Cycle length desired: Approximately 60 seconds

Speed desired: Approximately 30 mph (not to exceed 30 mph)

60% of cycle is green on East-West streets

40% of cycle is green on North-South streets

Required: To provide a coordinated network, determine:

- (1) Cycle length to nearest 5 seconds
- (2) Progression speeds
- (3) Signal offsets written on diagram

Dept. of Civil Engineering Kansas State University Manhattan, Kansas 66506

subject

LAB EXERCISES IN TRAFFIC ENGINEERING

title

PARKING STUDIES - PROBLEM STATEMENT

Attached are two work problems on parking studies. The problems are required to be worked to supply details wanted in the statements. Procedures and other necessary data to be used in the solution of these problems may be studied in the following references:

- 1. "Traffic Engineering Theory and Practice" by Louis J. Pignataro Chapter 16.
- 2. "Traffic Engineering Handbook" by ITE Chapter 12.
- "Manual of Traffic Engineering Studies" by ITE -Chapter 6.
- 4. "Conducting a Limited Parking Study" NCUT Procedure Manual 3C.

PROBLEM 1

A one-day parking usage and turnover study was conducted in the CBD of a small city, between the hours 10 a.m. to 6 p.m. Each space was inventoried once an hour to determine if a vehicle was parked, and if it was the same vehicle recorded in the previous round. All the curb stalls had a 2-hr. parking limit.

An analysis of parking meter revenues for the day of study indicated that the day's earnings were equal to 90% of the average day for on-street and 85% for off-street facilities.

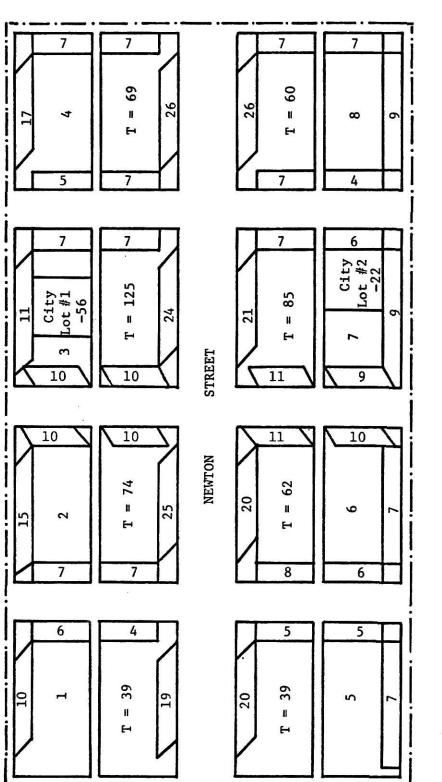
The data collected during study is given in Fig.VII-1 and Table VII-1. You are required to analyze the given data, to calculate the following:

- i) Percent usage for each block.
- Turnover for each block.
- iii) What will you expect the turnover to approach as a limit?
 - iv) If the efficiency factor for curb stalls is 0.85 and for lots is 0.75, find the practical space hours in each block.
- (b) Due to an increase in traffic demand, it has been decided to change existing 45° angle parking along Newton Street to parallel metered spaces, with the same 2-hr. limit. You are required to examine the revised situation and suggest a proper solution to the problem posed due to reduction in curb spaces. Use Fig. 16-2 'Pignataro' for typical space dimensions.

Table VII-1

Block Number	Available Spaces	Space Hours Used	Number of Parkers
1	39	98	51
2	74	308	199
3	125	668	388
4	69	321	232
5	39	132	71
6	62	220	150
7	85	486	331
8	60	268	214

•



CBD PARKING INVENTORY

Angle Parking
Parallel Parking

Fig. VII-1

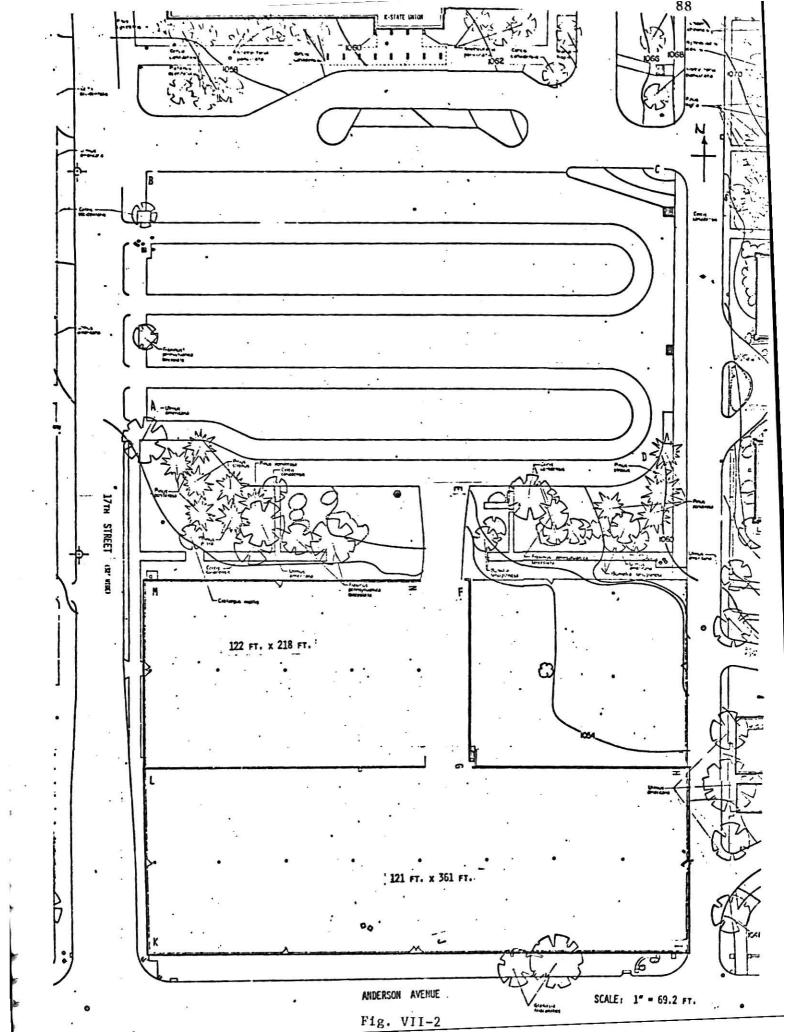
PROBLEM 2

A sketch of existing parking lot, south of K-State Union building is given in Fig. VII-2 Assuming that the portion ABCDE is satisfactory, design the portion EGHIKM, with the sole objective of accommodating maximum number of cars.

All entrances and exits are to be provided along AE only.

Show the detailed layout on a 11" \times 8 1/2" sheet and give the total number of parking spaces provided.

More than one parking angle may be used if necessary to maximize space utilization. Use Table 16-1 of textbook for typical parking lot capacity figures. Any more information regarding standards may be obtained from Chapter 12 of "Traffic Engineering Handbook."



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subject

LAB EXERCISES IN TRAFFIC ENGINEERING

title

INTERSECTION DESIGN AND CONTROL-PROBLEM STATEMENT

Attached is a problem on the design of a diamond interchange. All the features concerning its design and control may be worked out. Procedures and other relevant information necessary may be studied in the following references:

- "A Study of the Peaking Characteristics of Signalized Urban Intersections as Related to Capacity and Design," by Donald R. Drew and Charles Pinell, Texas Transportation Institute Journal.
- 2. "The Value of Signal Phase Overlap in Signalized Intersection Capacity," a paper by Charles Pinell.

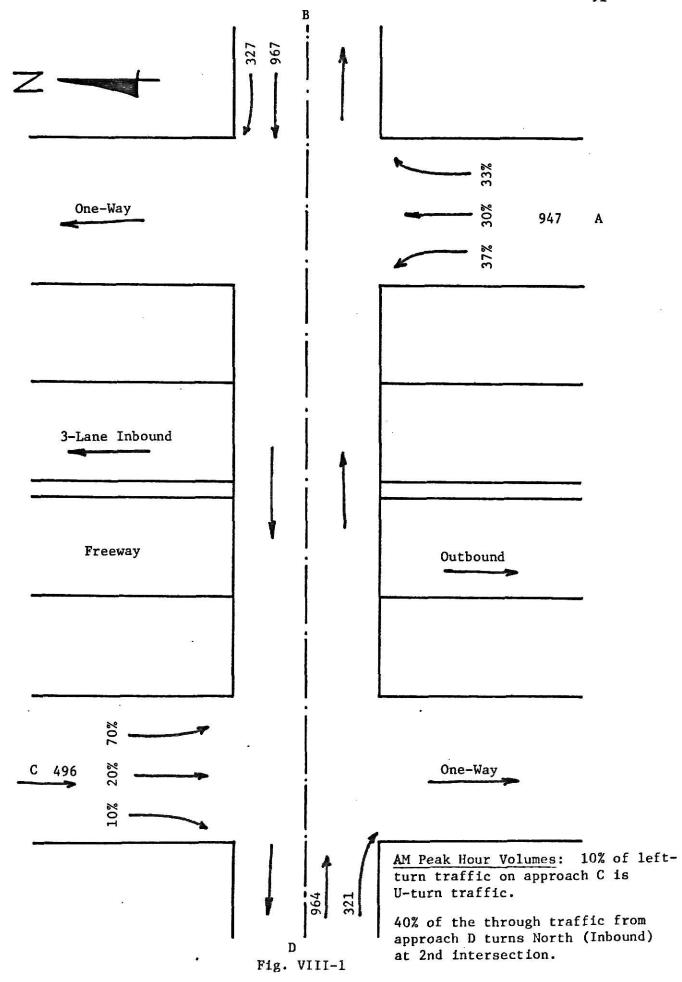
PROBLEM 1

A diamond interchange is to be constructed, in a city of population 800,000, approximately 4 miles away from the CBD, on a radial freeway. Distance of the location from city limits is 8 miles.

Volumes to be handled by the proposed interchange are shown on the attached sketch.

Design the interchange for signalization. This will include determining the number of lanes on each approach, indicating the traffic control devices to be used such as paint markings, lane control signs, signal head locations, and channelization. You may add such things as special turn lanes and U-turn lanes, if justified.

All design features should be shown on a 20" x 16" pencil sketch.



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subject

LAB EXERCISES IN TRAFFIC ENGINEERING

title

ACCIDENT STUDIES - PROBLEM STATEMENT

Attached is a set of accident reports. These accident reports were found in the intersection accident file of Ballard Road and Milwaukee Avenue in Niles, Illinois, for the calendar year 1968.

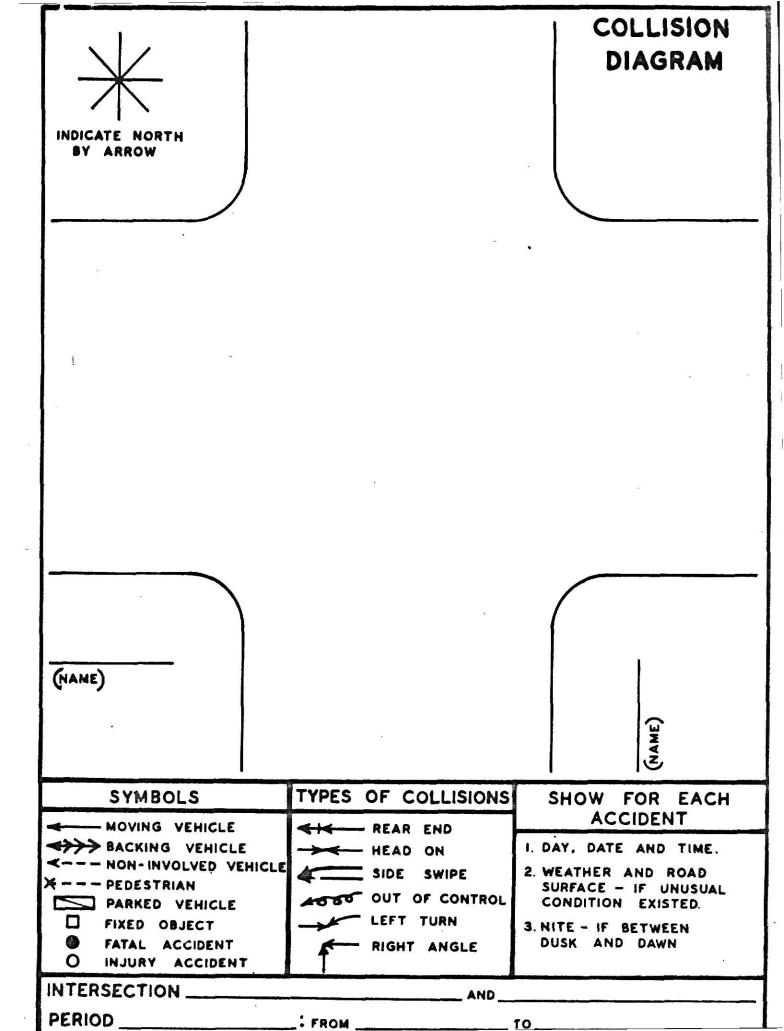
You are required to go through the enclosed reports and prepare the following:

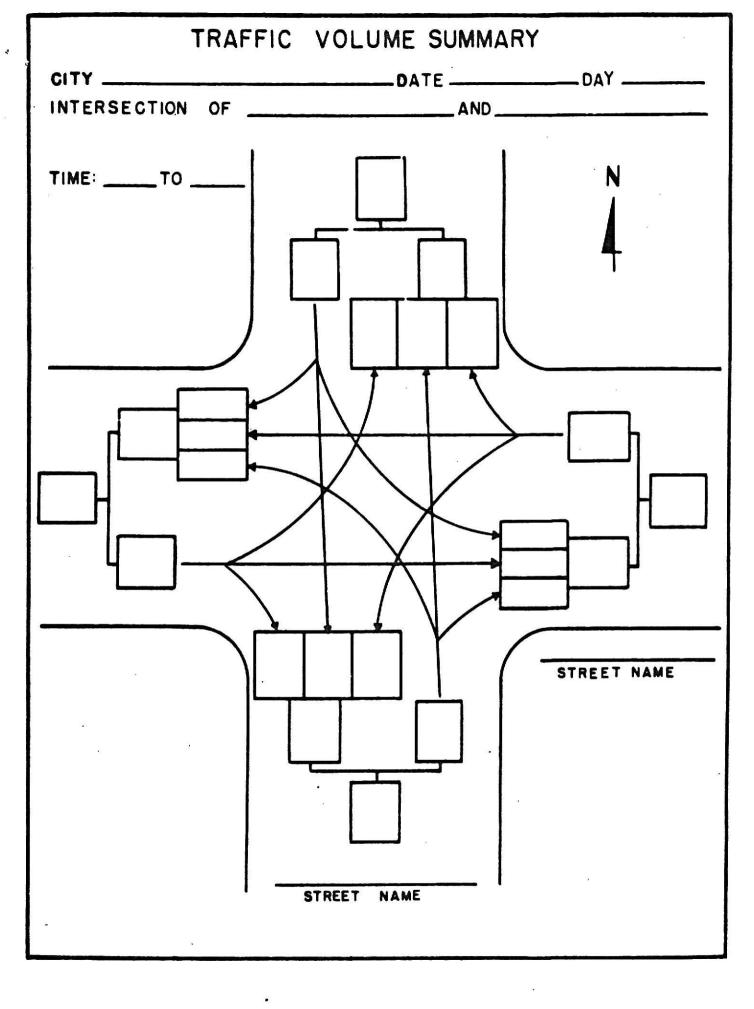
- 1) A collision diagram for this intersection, showing only the accidents which you believe to be properly associated with the intersection.
- 2) Traffic volume summary
- 3) Summary of the accident facts, relevant to the solution of this particular accident location.
- Analysis of collision diagram and accident summary.
- 5) Give step by step procedure to suggest remendial measures for improving the accident situation at this location.

The following references may be studied to proceed with the above problem:

- 1) "Manual of Traffic Engineering Studies," by ITE, Chapter 1.
- 2) "Traffic Engineering Handbook," by ITE Chapter 6.
- 3) "Traffic Engineering Theory and Practice" by Louis J. Pignataro, Chapter 17.
- 4) "Fundamentals of Traffic Engineering," by Kennedy, Kell and Homburger.

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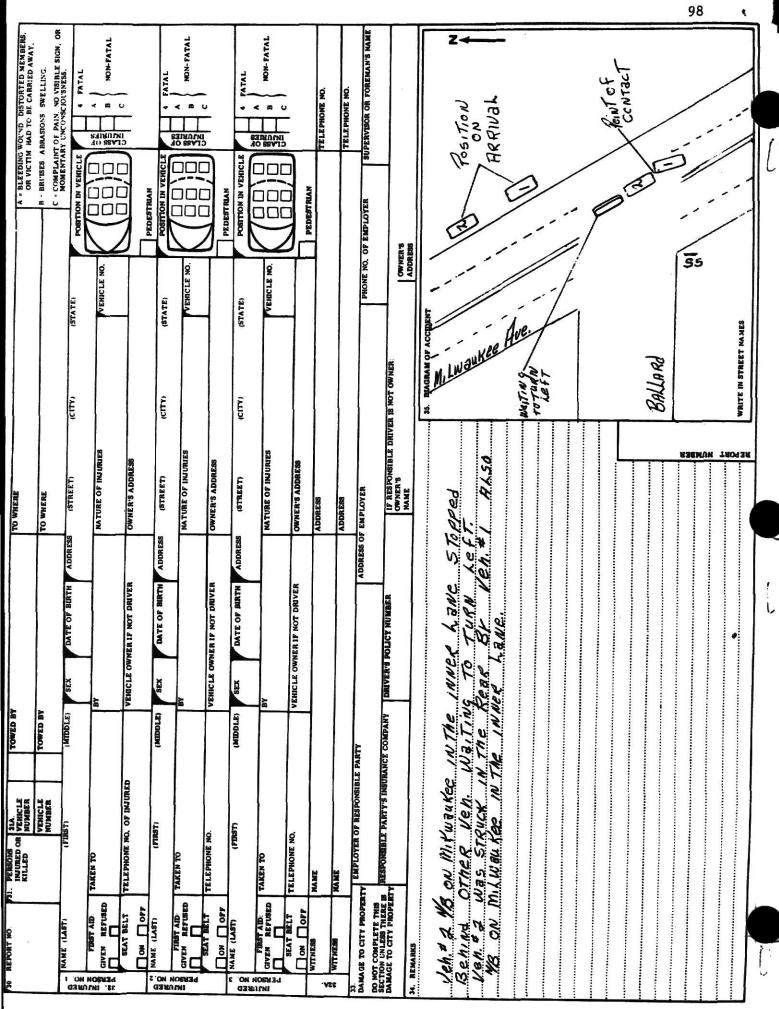




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NILES POLICE DEPARTMENT ACCIDENT REPORT

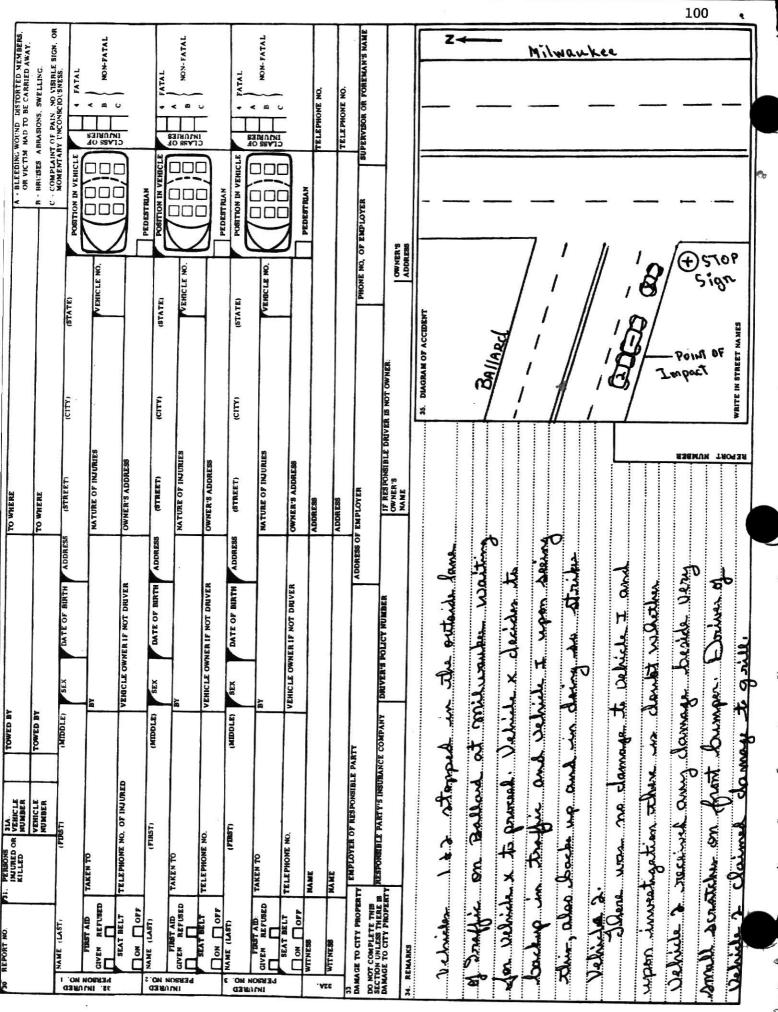
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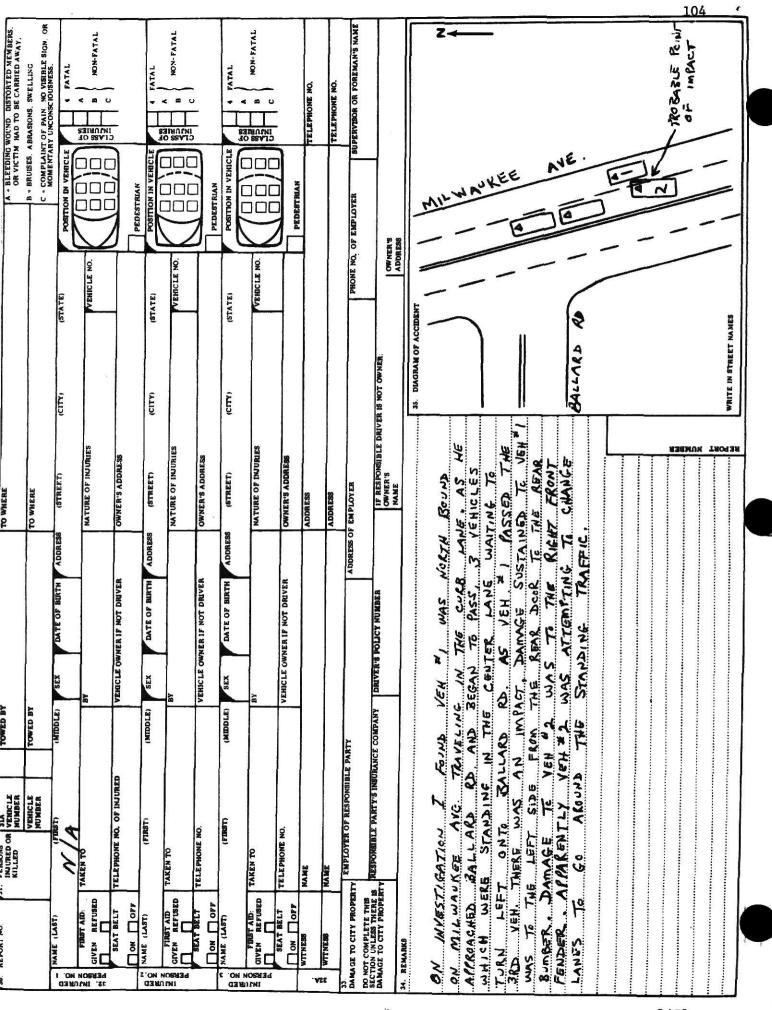
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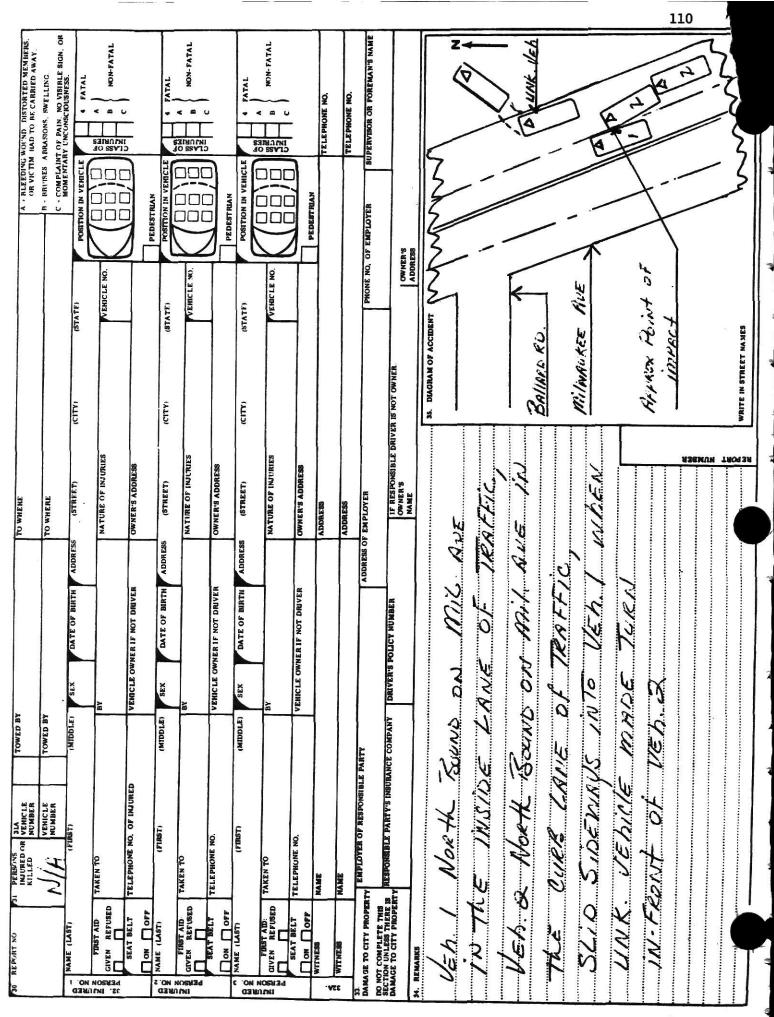
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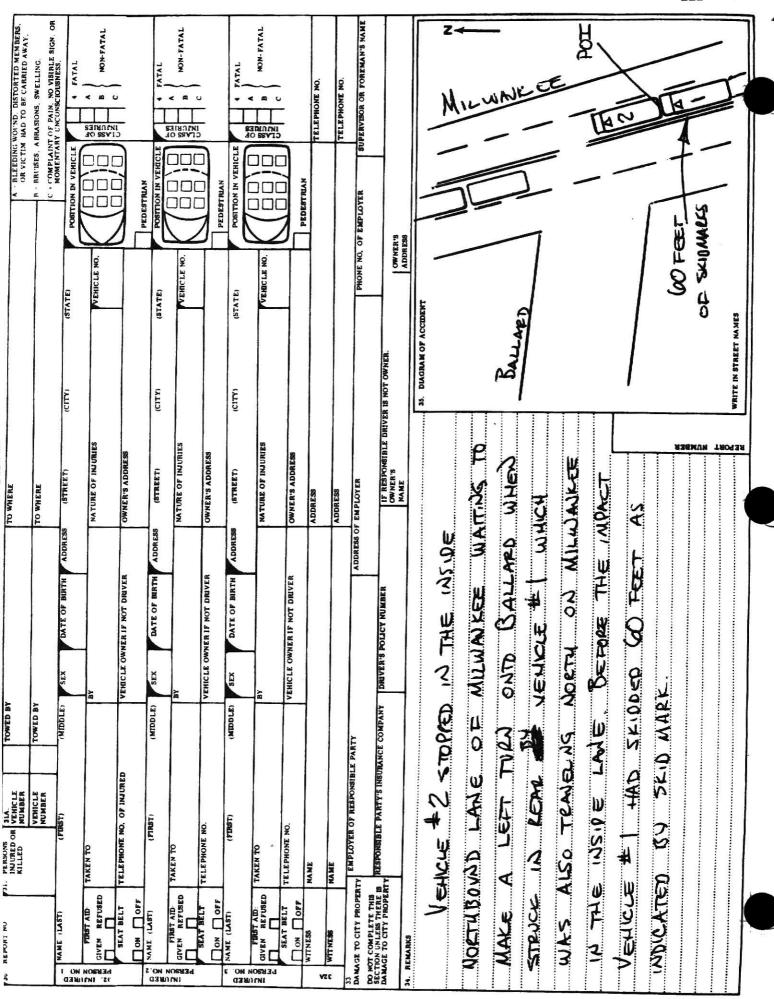


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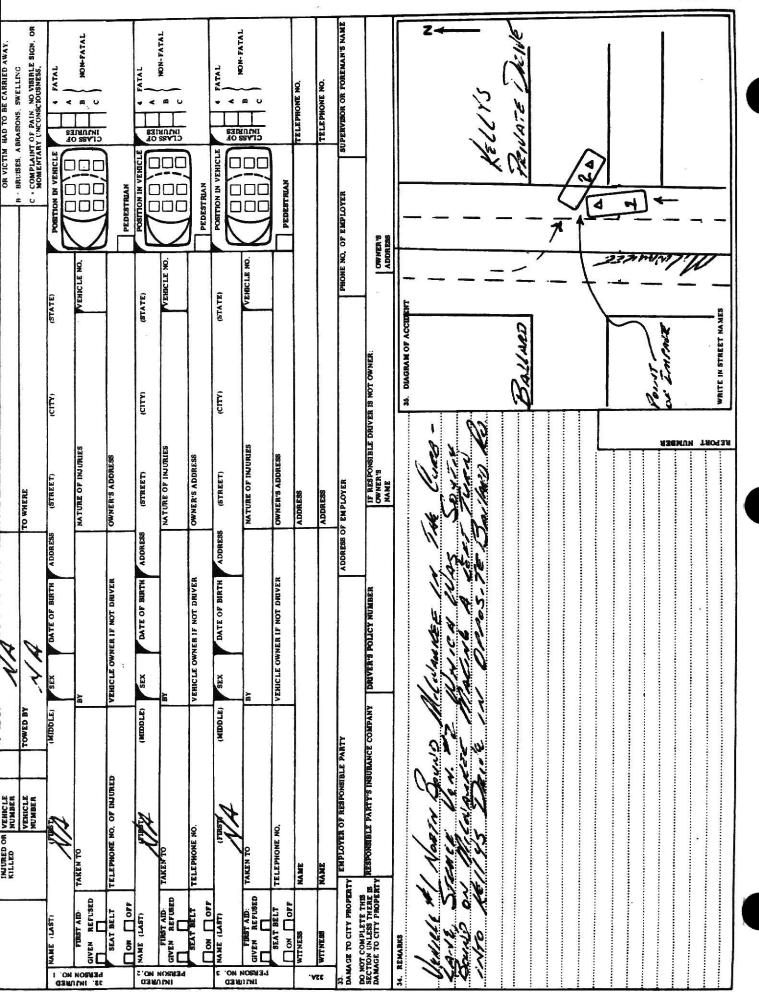
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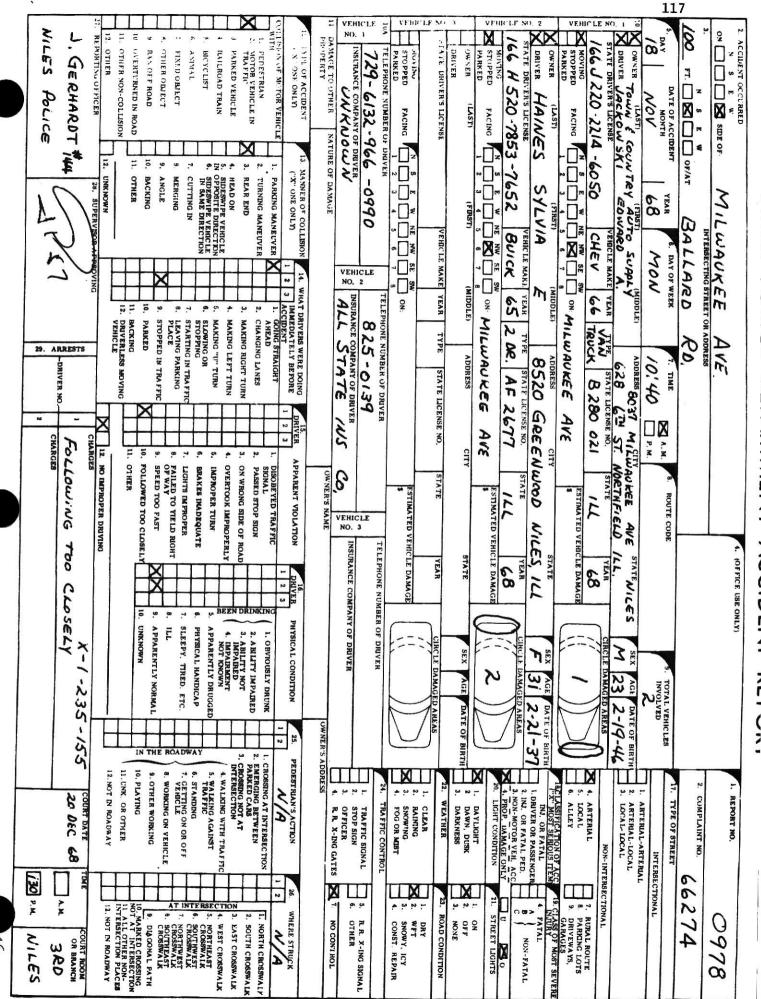
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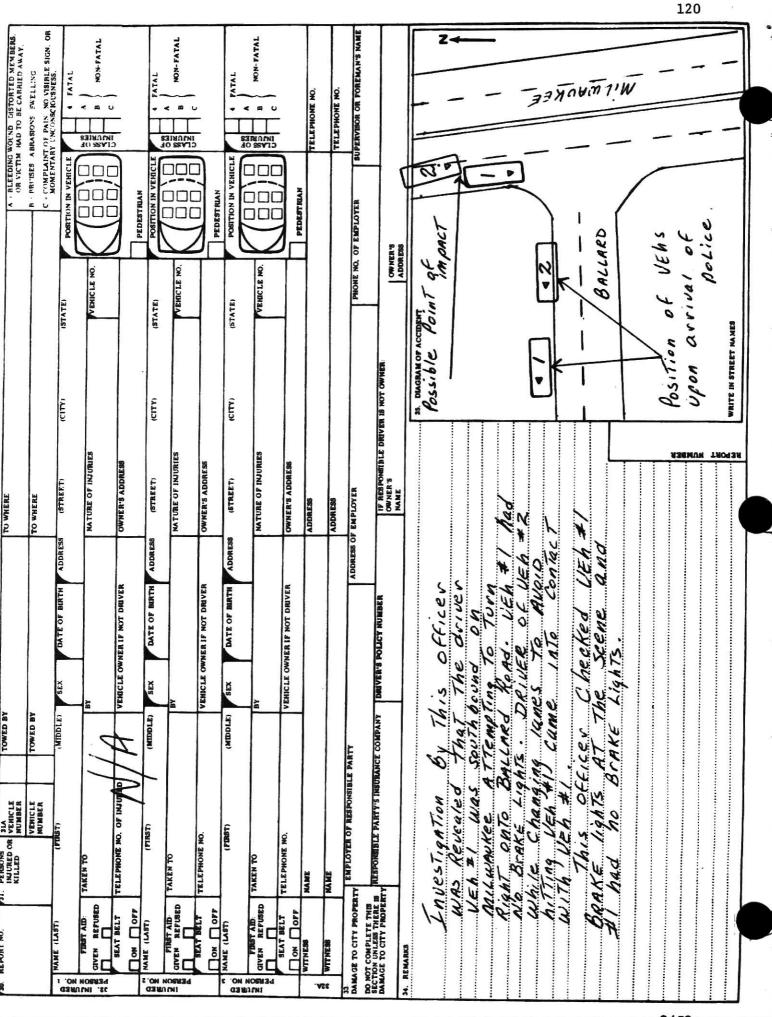




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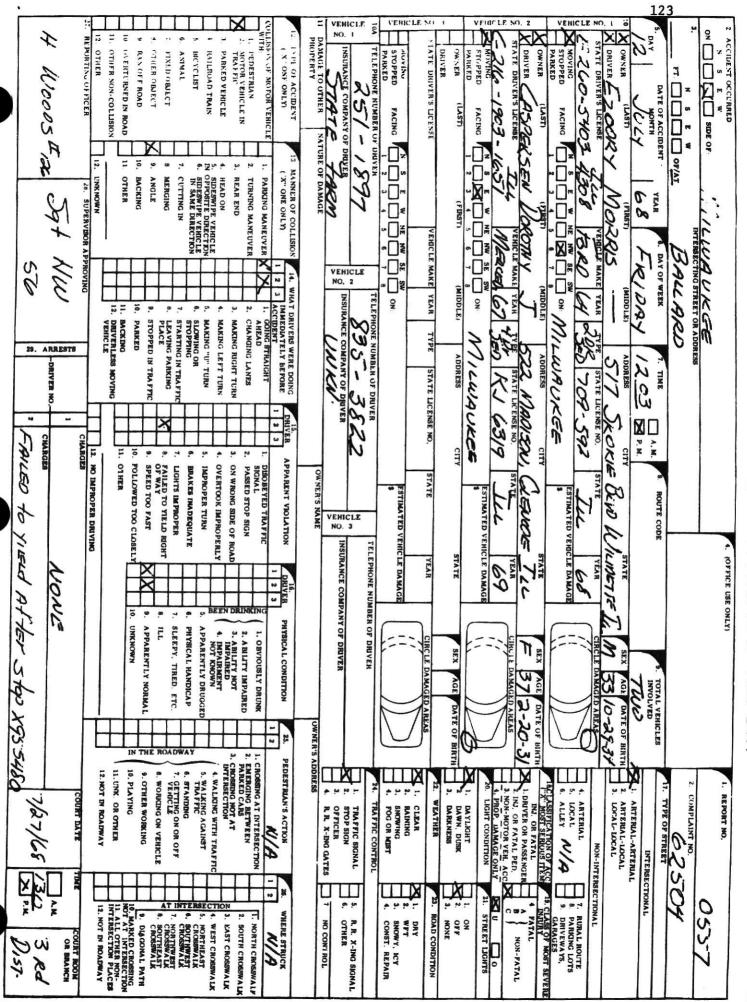
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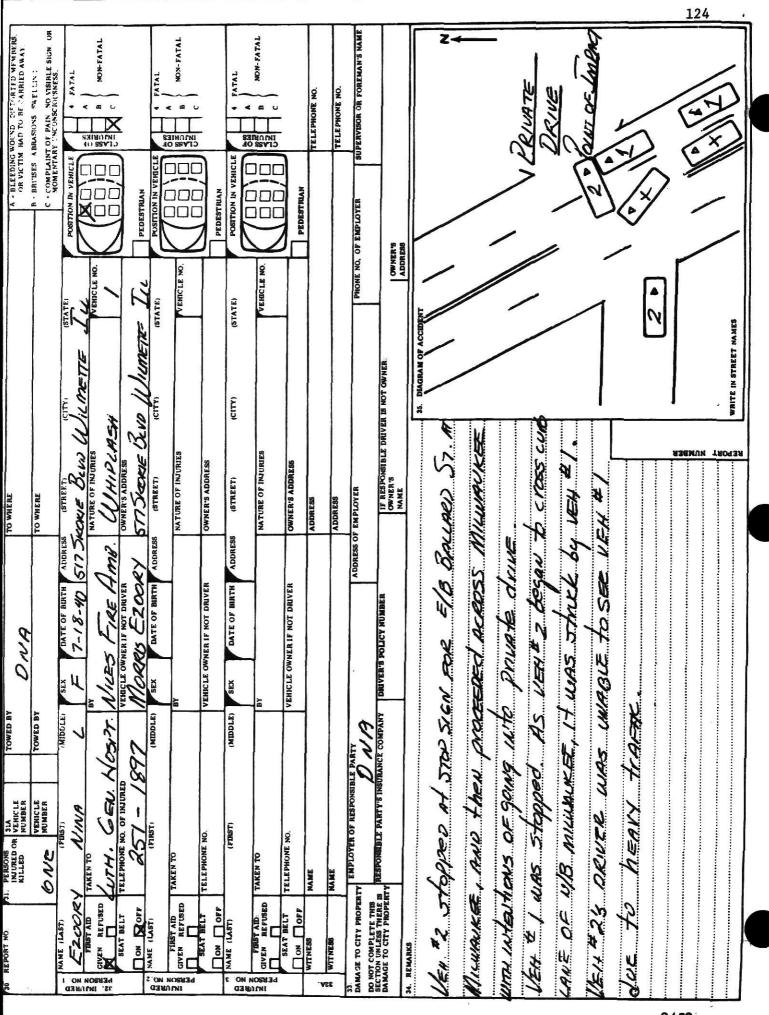


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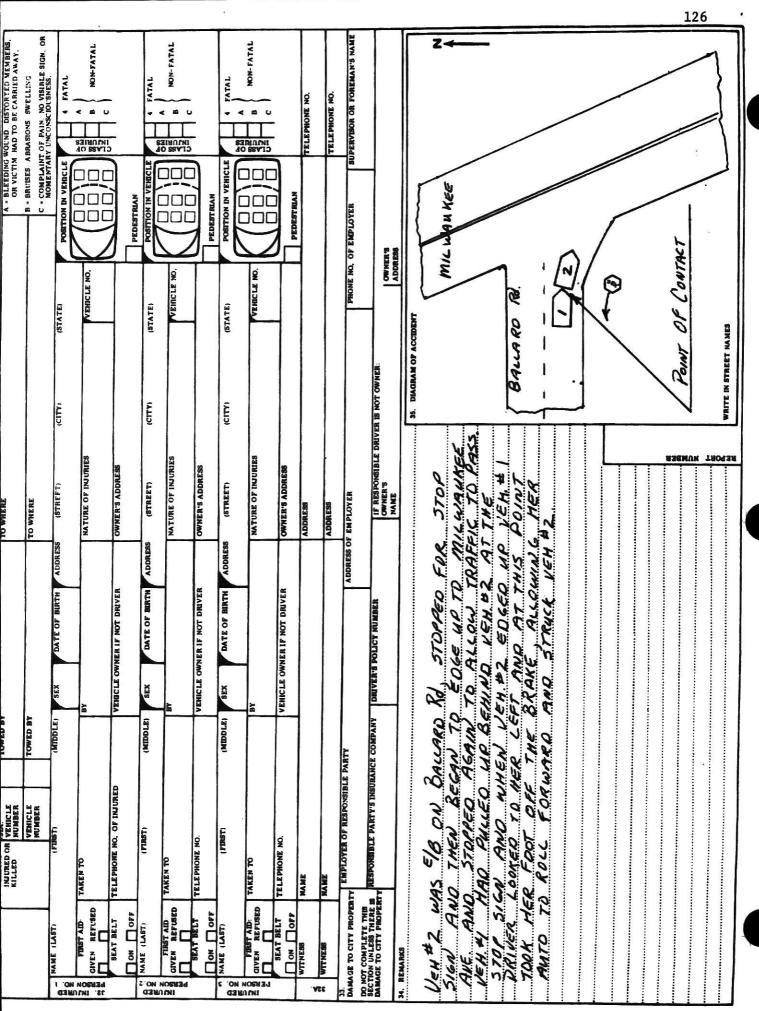
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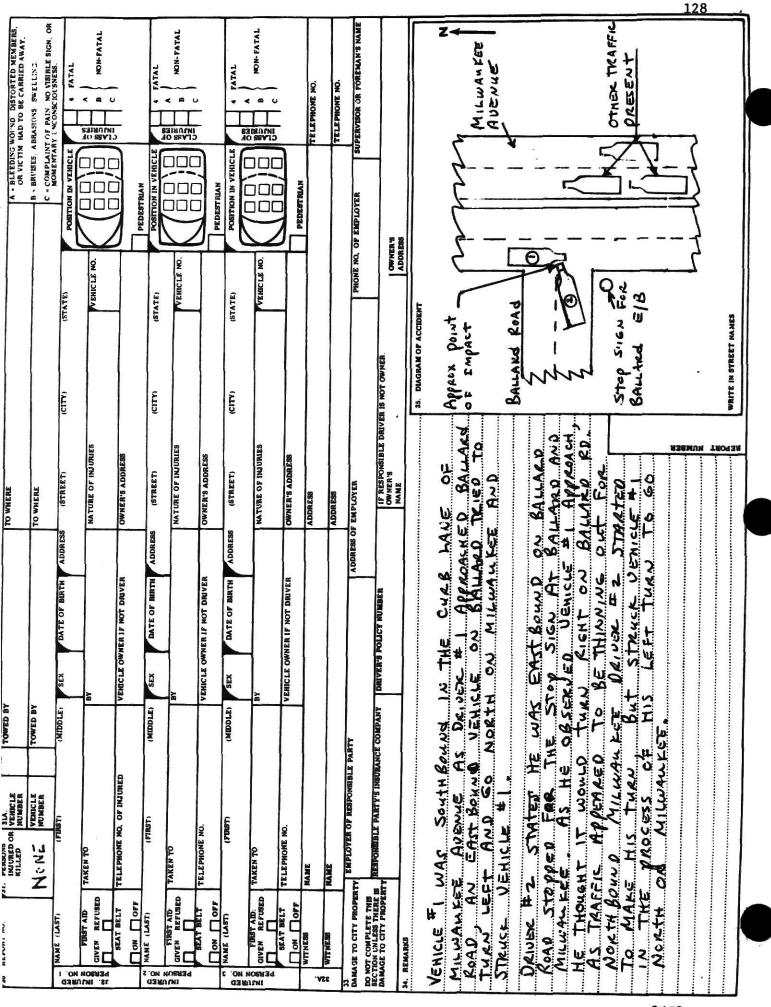
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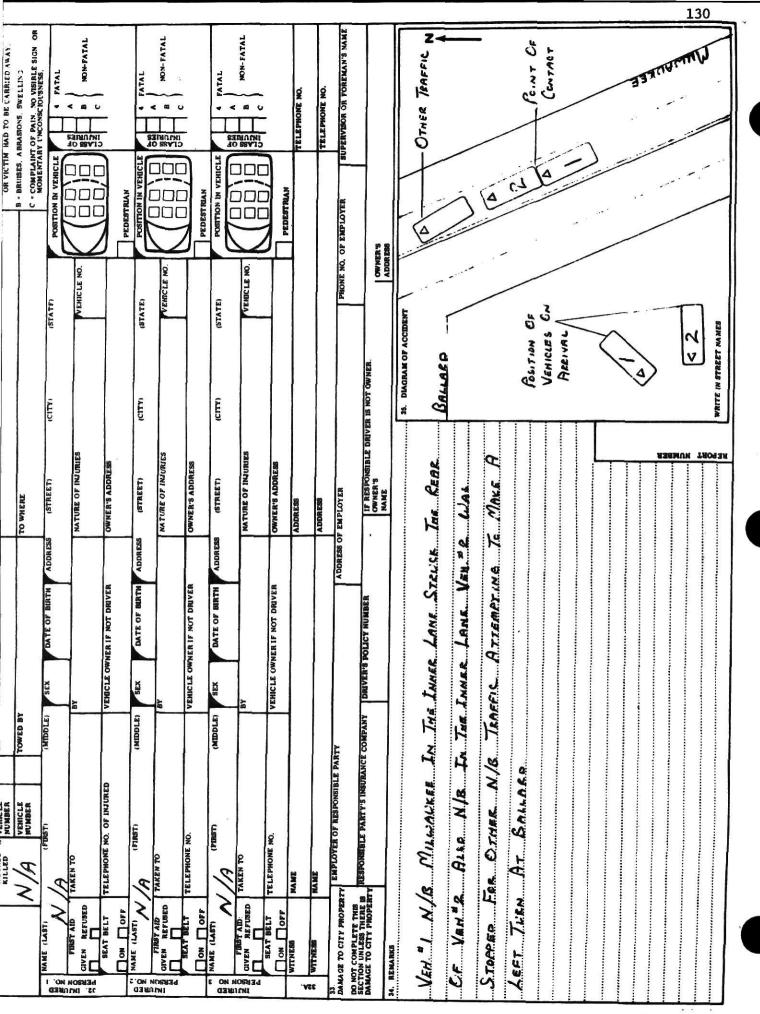
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LAB EXERCISES IN TRAFFIC ENGINEERING

by

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AN ABSTRACT OF A MASTER'S REPORT

submitted in partial fulfillment of the requirements for the degree

MASTER OF SCIENCE

Department of Civil Engineering

KANSAS STATE UNIVERSITY

Manhattan, Kansas

ABSTRACT

The purpose of this report is to equip the Department of Civil

Engineering at Kansas State University with a set of lab exercises to

be used for an M. S. course, Traffic Engineering I. Excepting "Highway

Capacity" all topics covered in the course have been included in 9

Chapters as below:

- I Volume Studies
- II Speed Studies
- III Travel Time and Delay Studies
 - IV Intersection Delay Studies
 - V Intersection Sight Distances
- VI Traffic Signal Systems and Networks
- VII Parking Studies
- VIII Intersection Design and Control
 - IX Accident Studies
- 2. Efforts were made to collect data used in exercises from real life situations to give the student a feel of problems he may be called upon to tackle in his profession. Field exercises were undertaken in Manhattan, for Speed and Travel Time and Delay Studies while real data from published studies has been used in problems on Parking and Accident Studies. In a few exercises of supplemental value, where the aim has been to clarify the definitions of various significant terms, data has been fabricated. Statistical checks, where necessary, have been applied to test the validity of data.
- 3. Care has been taken to limit the scope of each problem so that a student could work out its solution in one or two three-hour lab sessions. Actual solutions will depend upon availability of funds, equipment and personnel with the organization and will involve various administrative and community

decisions like demolition of structures, aesthetic requirements of a city, trade-offs involved at various stages in long-range solutions, coordination with concerned agencies, expectation level of people and public reaction.

4. Volume Studies contain three problems, one on computation of AADT from coverage counts using daily and seasonal expansion factors, one on setting up traffic counting schedule for the city of Manhattan and one on intersection volume studies.

Speed Studies include six problems. First four problems involve various analyses of spot speed data and the last two require computation of Time Mean Speed and Space Mean Speed. A knowledge of precise distinction between the two speeds is very important to a traffic engineer to avoid any danger of comparing the two statistics, at a particular location, during two different years, where the statistics are based on speeds and the speeds in the two cases have been calculated by two different methods.

A problem on Travel Time and Delay Studies requires detailed analysis of travel time study data collected by average car method while another problem defines commonly used terms for various types of delays and speeds.

Intersection Delay Studies include a problem detailing the calculator method. Problem of visibility on intersections has been approached in an exercise on Intersection Sight Distances.

Time space diagrams have been used for timing the progression system for a balanced and for a preferential situation in chapter on Traffic Signal Systems and Networks.

An exercise on Parking Studies requires analysis of usage and turnover study data, while another exercise involves design of a parking lot.

The partial design of a diamond interchange has been worked out by a method outlined by Texas Transportation Institute, and probability of

cycle failure curves have been used for cycle split in a problem on Intersection Design and Control.

Lastly, a problem on Accident Studies requires step by step approach to improve a high accident location.