National Examinations – December 2016

98-Civ-B10 Traffic Engineering

<u>3 Hour Duration</u>

NOTES

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer book a clear statement of any assumptions made.

2. Any data required, but not given, can be assumed.

3. This is an **"OPEN BOOK"** examination. Any non-communicating calculator is permitted.

4. A total of **five** solutions is required. Only the first five as they appear in your answer book will be marked.

5. All questions are of equal value.

<u>Grading Scheme:</u>

Question 1 (a) to (e) – 4 marks each

Question 2 (a) to (e) – 4 marks each

Question 3 – 20 marks

Question 4 – 20 marks

Question 5 (a) to (e) – 4 marks each

Question 6 (a) – 6 marks, (b) and (c) – 7 marks each

Question 7 (a) to (h) – 2.5 marks each

1. Define and discuss each of the following:
   a) Leading protected phase vs. lagging protected phase
   b) Protected phase vs. permissive phase
   c) Bicycle lanes vs. bicycle paths
   d) HOV lanes
   e) Cordon counts vs. screenline counts

2. The following data in the following table was collected using the moving vehicle method of estimating traffic volume and travel time studies.

Run Direction / Number	Travel time (min)	No. of vehicles traveling in Opposite Direction	No. of vehicles that overtook the test vehicle	No. of vehicles overtaken by the test vehicle
Eastbound				
1	2.71	100	3	2
2	2.50	95	2	1
3	2.81	110	3	2
4	2.63	97	0	1
5	3.10	108	2	1
6	3.13	103	2	1
7	2.93	116	3	2
8	2.83	99	1	2
Westbound				
1	2.95	97	1	2
2	3.13	115	2	1
3	3.23	113	3	2
4	2.85	99	0	1
5	3.07	95	2	1
6	2.72	111	2	1
7	3.25	117	1	0
8	3.04	109	1	2

Using this data compute the following:

a) All average values for both westbound and eastbound trips.
b) Eastbound traffic volume (vehicles/hour)
c) Westbound traffic volume (vehicles/hour)
d) Average travel time of eastbound traffic (minutes)
e) Average travel time of westbound traffic (minutes)

3. For the traffic pattern shown in the tables below, determine an appropriate signal phasing system and phase lengths for the intersection using the Webster method. Show a detailed layout of the phasing system and the intersection geometry used.

Approach (Width)	**North (17 m)**	**South (17 m)**	**East (21 m)**	**West (21 m)**
Peak hour approach volumes				
Left turn	200	110	252	205
Through movement	630	560	845	774
Right turn	210	203	255	267
Conflicting pedestrian volumes	1350	1200	1200	1350
PHF	0.95	0.95	0.95	0.95

Lane type	**Saturation Flows (vphpl)**
Through	2400
Through-right	2100
Left	1500
Left-through	1800
Left-through-right	1600

4. Repeat question 3 given that the saturation flow rates are 20% higher and the pedestrian flow rates are 25% higher. How do these increases effect the cycle length?

5. Tim Hortons drive-through has only one lane open to take orders. When the manager is working the order window, she processes customers at a mean service rate of 46 customers per hour. The probability that the manager has free time to help clean the restaurant is 8%.
   a) What is the average number of customers that arrive per hour?
   b) How many customers on average are still waiting to order?
   c) Calculate the average number of customers in the drive-through line at Tim Hortons.
   d) Calculate the average wait time for a customer and the average time a customer spends in the drive through.
   e) If the probability is greater than 55% that more than 5 customers are waiting in line, Tim Hortons plans to build a second drive-through lane. Determine if a second drive-through lane is warranted.

6. Curves

Metric					US Customary				
			Stopping sight distance					Stopping sight distance	
Design speed (km/h)	Brake reaction distance (m)	Braking distance on level (m)	Calculated (m)	Design (m)	Design speed (mph)	Brake reaction distance (ft)	Braking distance on level (ft)	Calculated (ft)	Design (ft)
20	13.9	4.6	18.5	20	15	55.1	21.6	76.7	80
30	20.9	10.3	31.2	35	20	73.5	38.4	111.9	115
40	27.8	18.4	46.2	50	25	91.9	60.0	151.9	155
50	34.8	28.7	63.5	65	30	110.3	86.4	196.7	200
60	41.7	41.3	83.0	85	35	128.6	117.6	246.2	250
70	48.7	56.2	104.9	105	40	147.0	153.6	300.6	305
80	55.6	73.4	129.0	130	45	165.4	194.4	359.8	360
90	62.6	92.9	155.5	160	50	183.8	240.0	423.8	425
100	69.5	114.7	184.2	185	55	202.1	290.3	492.4	495
110	76.5	138.8	215.3	220	60	220.5	345.5	566.0	570
120	83.4	165.2	248.6	250	65	238.9	405.5	644.4	645
130	90.4	193.8	284.2	285	70	257.3	470.3	727.6	730
					75	275.6	539.9	815.5	820
					80	294.0	614.3	908.3	910

Note: Brake reaction distance predicated on a time of 2.5 s; deceleration rate of 3.4 m/s^2 [11.2 ft/s^2] used to determine calculated sight distance.

Source: AASHTO, 2001

a) Define the difference between a vertical curve, a horizontal curve, and a spiral curve.

b) A section of road is being designed with a vertical crest curve to join an entering grade of 4% grade to a departing 3% grade with a design speed of 80 km/h. Determine the minimum length of the curve that will provide adequate stopping sight distance. Assume that the driver's height is 1060 mm and the stopping sight distance is to be designed for small objects in the road with an average height of 100 mm.

c) A 150 m vertical crest curve is designed to connect a +4.5% tangent with a -2.5% tangent. What should the design speed be to provide ample stopping sight distance? Use standard heights for the driver and object of 1080 mm and 600 mm, respectively.

7. A signalized intersection has 90 second cycle time with a 27 second effective green. The intersection has a saturation flow of 2800 vph and the flow of the approach traffic is 600 vph. Using D/D/1 queuing determine the following values.

a) Verify that the capacity is greater than the arrival rate

b) Time to queue clearance after the start of the effective green

c) Proportion of the cycle with a queue

d) Proportion of vehicles stopped

e) Maximum number of vehicles in the queue

f) Total vehicle delay per cycle

g) Average delay per vehicle

h) Maximum delay of any vehicle