National Examinations – December 2017

16-Civ-B10 Traffic Engineering

3 Hour Duration

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.

Grading Scheme:

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) to (h) – 2.5 marks each

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

1. Define and discuss each of the following:

   a) Leading protected phase vs. lagging protected phase
   b) Time mean speed (TMS) vs. Space mean speed (SMS)
   c) Circular vs. Spiral curves
   d) HOV lanes
   e) Pedestrian clearance time

2. The Second Cup in University campus has only one cashier where customers arrive at a rate of 10 per 20 minutes. The cashier processes these customers at a mean service rate of 12 customers per 20 minutes.

   (a) What is the probability that the cashier is free?
   (b) How many customers on average are waiting to be processed?
   (c) Calculate the average number of customers in line.
   (d) Calculate the average wait time for a customer and the average time a customer spends being processed by the cashier.
   (e) If the line of customers is longer than five customers, a second cashier is opened, what is the probability of a second cashier being opened?

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. Assume lost time per phase due to acceleration and deceleration at phase changes is 3.5 seconds and that an all-red interval of 1.5 seconds is provided at each phase.

Approach (Width)	North (18 m)	South (18 m)	East (20 m)	West (20 m)
Peak hour approach volumes				
Left turn	235	205	220	220
Through movement	736	654	775	850
Right turn	217	311	342	351
Conflicting pedestrian volumes per hour	1000	985	1200	1345
PHF	0.95	0.95	0.95	0.95

Lane type	Saturation Flows (vphpl)
Through	2450
Through-right	2080
Left	1750
Left-through	1900
Left-through-right	1700

4. Repeat question 3 given that the saturation flow rates are 20% lower and the pedestrian flow rates are 10% lower. How do these decreases effect the cycle length?

5. The following table shows collected data using the moving vehicle method of estimating traffic volume and travel time studies. Using this data compute:

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)

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
Southbound				
1	3.04	108	2	1
2	2.80	103	3	2
3	3.15	119	1	2
4	2.95	105	3	2
5	3.47	116	0	1
6	3.51	111	2	2
7	3.28	125	2	1
8	3.17	107	3	1
Northbound				
1	2.68	93	2	1
2	2.85	109	1	2
3	2.94	108	0	2
4	2.59	94	3	1
5	2.79	90	1	0
6	2.48	105	2	1
7	2.96	111	1	1
8	2.77	104	2	2

6. An approach at a signalized intersection has a saturation flow of 2500 vph and the flow of the approach traffic is 500 vph. If the cycle time is 80 second with a 25 second effective green determine the following values using D/D/1 queuing:

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

7. Curves

Metric					US Customary				
	Brake reaction distance	Braking distance on level	Stopping sight distance			Brake reaction distance	Braking distance on level	Stopping sight distance	
Design speed (km/h)	(m)	(m)	Calculated (m)	Design (m)	Design speed (mph)	(ft)	(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/s² [11.2 ft/s²] used to determine calculated sight distance.

Source: AASHTO, 2001

a) Define Perception-Reaction Time and Braking Distance

b) A section of road is being designed with a vertical crest curve to join an entering grade of 5% grade to a departing 3% grade with a design speed of 60 km/h. Determine the minimum length of the curve that will provide adequate stopping sight distance. Assume that the driver's height is 1050 mm and the stopping sight distance is to be designed for small objects in the road with an average height of 500 mm.

c) A 225 m vertical crest curve is designed to connect a +3% tangent with a -3% 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.