National Examinations – December 2018

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

Question 3 – 20 marks

Question 4 (a) to (e) – 4 marks each

Question 5 (a) to (h) – 2.5 marks each

Question 6 (a) to (e) – 4 marks each

Question 7 – 20 marks

1. Define and discuss each of the following:

   a) Effective green and effective red
   b) Cordon counts vs. screenline counts
   c) Semi-actuated signal control vs. fully-actuated signal control
   d) Protected phase vs. permissive phase
   e) MUTCD (Manual on Uniform Traffic Control Devices for Streets and Highways), list and discuss 4 of the 8 warrants to be analyzed in determining whether a traffic signal is warranted at an intersection

2. 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/s² [11.2 ft/s²] 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 265 m vertical crest curve is designed to connect a +2% tangent with a -2% 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.
   c) A section of road is being designed with a vertical crest curve to join an entering grade of 1% grade to a departing -1% grade with a design speed of 120 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 300 mm.

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 (15 m)	South (15 m)	East (18 m)	West (18 m)
Peak hour approach volumes				
Left turn	115	369	214	185
Through movement	200	582	635	412
Right turn	192	360	400	365
Conflicting pedestrian volumes per hour	905	850	1200	1200
PHF	0.9	0.9	0.9	0.9

Lane type	Saturation Flows (vphpl)
Through	2515
Through-right	1895
Left	2002
Left-through	1775
Left-through-right	2366

4. 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 eastbound and westbound trips.
b) Westbound traffic volume (vehicles/hour)
c) Eastbound traffic volume (vehicles/hour)
d) Average travel time of westbound traffic (minutes)
e) Average travel time of eastbound 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
Westbound				
1	4.40	152	3	2
2	4.20	157	1	1
3	4.50	179	2	1
4	4.40	159	1	3
5	5.20	176	3	4
6	5.30	165	4	3
7	4.90	187	5	4
8	4.70	161	5	2
Eastbound				
1	4.10	129	1	2
2	4.20	165	2	1
3	4.20	164	2	3
4	3.90	142	3	2
5	4.20	137	2	1
6	3.70	156	4	2
7	4.40	168	3	2
8	4.10	155	3	3

5. An approach at a signalized intersection has a saturation flow of 2600 vph and the flow of the approach traffic is 650 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

6. A Starbucks has only one cashier where customers arrive at a rate of 3 per 6 minutes. The cashier processes these customers at a mean service rate of 4 customers per 6 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 3 customers, a second cashier is opened, what is the probability of a second cashier being opened?

7. Repeat question 3 given that the saturation flow rates are 10% higher, the pedestrian flow rates are 3% lower, and the approach width in all directions is 10 m. How do these changes affect the cycle length?