National Examinations –May 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 (d) – 5 marks each

Question 2 (a) to (e) – 4 marks each

Question 3 (a) to (e) – 4 marks each

Question 4 (a) and (b) – 10 marks each

Question 5 – 20 marks

Question 6 – 20 marks

Question 7 (a) and (c) – 4 marks each, (b) and (d) – 2 marks each, (e) – 8 marks

1. Define and discuss each of the following:
   (a) Peak hour factor
   (b) Protected phase vs. permissive phase
   (c) Cordon counts vs. screenline counts
   (d) PIEV

2. McDonald's on Main Street has only one drive thru lane. Customers arrive at a rate of 125 per hour during peak morning rush. The worker processes these orders at a mean service rate of 138 cars per hour.
   (a) What is the probability that the worker is free from processing an order during the rush?
   (b) How many cars on average are waiting to be processed?
   (c) Calculate the average number of cars in line.
   (d) Calculate the average wait time for a car and the average time a car spends waiting for their order.
   (e) If the line of cars waiting for their order is longer than six vehicles during peak hour it will back up on the street. What is the probability that the cars back up onto the street?

3. A large bridge has two lanes in each direction but a construction project will require the two outside lanes to be closed to replace the guiderails and barrier walls. The bridge with only one lane in each direction will provide enough capacity except for during rush hour between 7AM and 9AM or 5PM and 7PM. During morning rush hour, the traffic flow is 1500 vph but one lane only has a capacity of 1350 vph and after 9AM, the traffic flow drops to 800 vph. During the evening rush hour, the traffic flow is 1625 vph and after 7PM it drops to 700 vph.
   (a) What is the maximum length of the queue during morning rush hour?
   (b) What is the longest expected time any vehicle will spend in the queue on their way to work in the morning?
   (c) At what time will the morning rush hour queue dissipate?
   (d) What is the total delay from 7AM until the queue is cleared?
   (e) If you lived five minutes from the entrance of the bridge and you worked ten minutes past the exit of the bridge would you make it to work on time if you left at 8:30AM and started work at 9AM, assuming no other traffic delays other than the bridge?

4. 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) A 185 m vertical crest curve is designed to connect a +3.5% tangent with a -1.25% tangent. What should the design speed be to provide ample stopping sight distance?

(b) A section of road is being designed with a vertical crest curve to join an entering grade of 4.5% grade to a departing 3.5% grade with a design speed of 90 km/h. Determine the minimum length of the curve that will provide adequate stopping sight distance. Assume that the driver's height is 1200 mm and the stopping sight distance is to be designed for small objects in the road with an average height of 200 mm.

5. A signalized intersection has an approach saturation flow rate of 2770 vph. At the beginning of an effective red of one cycle, the approach has four vehicles waiting and vehicles arriving at a rate of 500 vph. The effective green is 15 second long and starts ten seconds after the vehicle queue reaches ten vehicles. What is the total delay for this signal?

6. 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 (18 m)	South (18 m)	East (20 m)	West (20 m)
Peak hour approach volumes				
Left turn	223	95	245	210
Through movement	595	555	835	732
Right turn	240	197	257	533
Conflicting pedestrian volumes	1225	1100	1100	1225
PHF	0.95	0.95	0.95	0.95

Lane type	Saturation Flows (vphpl)
Through	2300
Through-right	2150
Left	1650
Left-through	1850
Left-through-right	1650

7. Intersections

(a) A four-legged intersection has two lanes in each direction and a two-phase cycle. One phase of the intersection has two lanes, one for left-turns and straight-through traffic and the other lane for right-turns and straight-through traffic. The design flow rates and saturation flow rates are found below. Calculate the critical flow ratio for this phase and determine which lane is the critical lane.

Lane Description	Design Flow Rate (pcu/hr)	Saturation Flow Rate (pcu/hr)
NB – L,S	550	1350
NB – R,S	450	1650
SB – L,S	400	1200
SB – R,S	745	1450

(b) An intersection approach has 3 lanes, permitted left turns, 18% left turns with a through vehicle equivalent of 7.25, and a saturation flow rate of 2150 vphgpl (vehicle per hour of green per lane) for through vehicles under prevailing conditions. What is the left turn adjustment factor for the intersection?

(c) For the intersection in part (b), determine the saturation flow rate and saturation headway for the approach, including impact of left-turning vehicles.

(d) For the intersection in part (b), if the effective green time is 50 seconds in a cycle with a length of 80 seconds, what is the capacity of the approach in vehicles per hour?

(e) A two-phase cycle has the same saturation flow rate for each phase and a total available green time of 80 seconds. Calculate the available green time for each of the two phases using the data in the following table.

Intersection Number	Phase 1 Flow Rate (pcu/hr)	Phase 2 Flow Rate (pcu/hr)
1	350	185
2	325	115
3	175	45
4	95	85