National Examinations – December 2015

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 (a) to (e) – 4 marks each

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

Question 5 – 20 marks

Question 6 (a) to (d) – 5 marks each

Question 7 (a) to (e) – 4 marks each

1. Define and discuss each of the following:
   (a) Effective green and effective red
   (b) Time mean speed (TMS) vs. Space mean speed (SMS)
   (c) Semi-actuated signal control vs. fully-actuated signal control
   (d) PIEV
   (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. A bank has only one teller window where customers arrive at a rate of 15 per hour. The teller processes these customers at a mean service rate of 17 customers per hour.
   (a) What is the probability that the teller is free from processing a customer?
   (b) How many customers on average are waiting to be processed?
   (c) Calculate the average number of customers in the bank.
   (d) Calculate the average wait time for a customer and the average time a customer spends in the bank.
   (e) What is the probability of more than 4 people in line?

3. On Highway 401 there is a disabled vehicle that blocks one of the two EB lanes at 5:05 PM. At that time, the capacity of the highway is reduced to 960 vph from 2400 vph. The EB flow rate at this time of day is 2100 vph. The vehicle is towed away after 20 minutes.
   (a) Sketch a queuing diagram to determine if a queue formed, and if so, what was its maximum queue length (maximum number of vehicles in the queue)?
   (b) At what time did the queue clear?
   (c) Calculate the longest wait time for any vehicle in the queue.
   (d) Calculate the total vehicle delay and the average delay per vehicle.
   (e) If a vehicle entered the queue at 5:23 PM, how many vehicles would be ahead of it in the queue and how long would that driver have to wait?

4. Curves

   (a) A 200 m vertical crest curve is designed to connect a +4.5% tangent with a -2% tangent. What should the design speed be to provide ample stopping sight distance?

   (b) A curve length is 2 km long, the height of the driver is 1.08 m, and the height of the object is 1.3 m. If the design speed of the crest vertical curve is 100 km/h and the entering grade is +3% and the exiting grade is -2%, does a "no passing zone" sign need to be erected?

5. A signalized intersection has an approach saturation flow rate of 3250 vph. At the beginning of an effective red of one cycle, the approach has five vehicles waiting and vehicles arriving at a rate of 800 vph. The effective green is 17 second long and starts 7 seconds after the vehicle queue reaches 10 vehicles. What is the total delay for this signal?

6. An isolated intersection with four one-lane approaches where no turns are permitted. The lanes are all 4 m wide with 3 m wide crosswalks in all directions and the vehicles are required to stop 1 m before the crosswalks. The speed limit is 50 km/h for all approaches and there are no grade changes at the intersection. The average passenger car carries 2 people and the average buses occupancy is 30 persons per bus in the NB direction and 15 persons per bus in the SB direction. See the table below for flow information for the intersection:

Approach Lane	Flow of passenger cars per hour	Flow of buses per hour
NB	1000	17
SB	600	10
EB	400	0
WB	800	0

(a) Calculate the arrival flow in veh/h, pcu/h, and persons per hour for all directions.

(b) The basic saturation flow rate for the intersection is 2200 pcu/h, calculate the adjusted saturation flow rate in veh/h for all approaches.

(c) The cycle is a 2-phase operation with a standard amber interval of 3.0 s and a clearing speed of 36 km/h. The average length of a passenger vehicle is 6.0 m long. Calculate the all red interval, the intergreen period, and the intersection lost time.

(d) Calculate the intersection flow ratio

7. For the intersection in the previous question (Question 6).

(a) There is no pedestrian refuge. Calculate the minimum cycle time for pedestrians for the intersection in question 6.

(b) If a cycle time of 90 seconds is chosen, determine the green allocation for each phase based on vehicular flow.

(c) Check whether these green intervals allocate enough time for the pedestrians.

(d) Calculate the lane capacity (pcu/h) and degree of saturation for each of the four directions of traffic.

(e) Calculate the average overall delay of the intersection in s/pcu.