National Exams May 2009

98-Civ-B10, Traffic Engineering

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
2. This is an OPEN BOOK EXAM. Any non-communicating calculator is permitted.
3. FIVE (5) questions constitute a complete exam paper. The first five questions as they appear in the answer book will be marked.
4. Each question is of equal value.
5. Most questions require an answer in essay format. Clarity and organization of the answer are important.

QUESTION 1

The density-speed relationship for a freeway lane was found to be:

$$k = 200 - 45 \ln u$$

Given that the speed is in kilometres per hour and the density is in vehicles per kilometre, sketch the speed-density, speed-flow and flow-density curves and determine:

a. speed at capacity

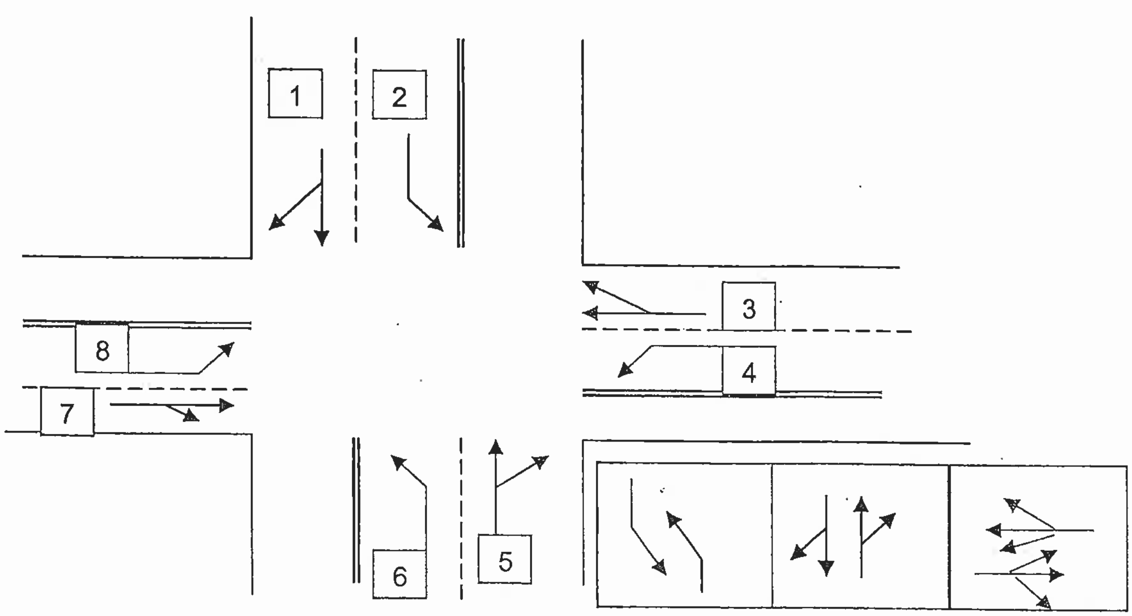
b. density at capacity

c. free flow speed

d. maximum flow

QUESTION 2

For the following intersection and demand table, using Webster's Equations as shown below, determine the minimum and optimum cycle time and the green split. Assume a three phase timing plan as shown with 5 seconds of inter green per phase and a maximum cycle length of 120 seconds. Assume the start losses and the end gains are equal. Ignore left turn sneakers and Right Turn on Red. Using a queuing diagram, calculate the total and average delay for lane 1.



Lane	1	2	3	4	5	6	7	8
Volume	450	150	275	55	325	125	400	75
Saturation Flow	1650	1500	1700	450	1600	1450	1850	550

$$C_{\min} = \frac{L}{1-\sum y_{ci}}$$

$$C_{opt} = \frac{1.5L+5}{1-\sum y_{ci}}$$

$$g_i = \frac{y_{ci}}{\sum y_{ci}}(C-L)$$

Where:

C_{min}	=	Minimum Cycle time (s)
C_{opt}	=	Optimum Cycle time (s)
y_{ci}	=	Critical Flow Ratio "y" for phase "i"
y_{ji}	=	Flow ratio for lane "j" in phase "i", given by ratio of Demand Volume to Saturation flow rate for lane "j" in phase "i"
L	=	Total Lost time per cycle (s)
g_i	=	Green time for phase "i" (s)

QUESTION 3

Discuss in detail each of the following:

a. Field techniques for Travel Time Studies

b. Vehicle Volume Counting methodologies

c. Space Mean Speed versus Spot Mean Speed

d. Methodologies and criteria used in coordinating traffic signal lights.

e. Design parameters used in geometric design of Circular Curves

QUESTION 4

A traffic stream travelling at 50 kph and a flow of 1000 vph encounters an accident that blocks its lane. This condition lasts for 20 minutes after which the accident is cleared and the traffic is allowed to discharge from the queue at rate of 1800 vph at 30 kph. If the jam density is 110 vpk, calculate;

a. maximum number of vehicles in the queue,

b. maximum length of the queue,

c. time to dissipate the queue, and

d. time until upstream conditions reach the site of the accident

QUESTION 5

The complexity of urban traffic requires the extensive use of computer tools and simulation software. Discuss in detail any five of the following:

a. TRANSYT

b. SCOOT

c. NETSIM

d. SYNCHRO

e. HCS

QUESTION 6

Discuss in detail each of the following:

a. Car following behaviour and how it impacts lane capacity

b. Free Flow speed, Jam Density, Speed and Density at Capacity

c. Concept of Level of Service (LOS) as it pertains to uninterrupted highway flow

d. Ramp Metering and its impact on freeway traffic flow.

e. Recurring and Non-Recurring Congestion

QUESTION 7

A two way East-West arterial provides for traffic signals A, B, and C after 200, 400 and 300 meters in the eastbound direction. There are two lanes in each direction with a speed limit of 36 kph and a saturation flow rate of 1800 vehicles/hour/lane. There are no mid block flows and no turning movements. If the street runs on a 100 second cycle and provides a 50:50 phase split with 5 seconds of inter green per phase;

a. produce a "to scale" space-time diagram showing the relationship between the distance and time within the cycle for offsets for Signal A, B and C of 0, 10, and 20 seconds respectively in the east bound direction. All offsets are related to Signal A and indicate the start of green for the E-W green,

b. label on this plot the expected path of the eastbound and westbound platoons,

c. based on a visual review of the space time diagram, estimate to the nearest five seconds the optimum offsets to optimise flow in the eastbound direction.

d. given that eastbound arrivals at Signal A occur at a uniform rate of 900 vehicles per hour (450 vehicles per hour per lane), compute the following

   i. the arrival pattern at B, using time "0" as the start of the Eastbound green at A.

   ii. the queuing diagram at B

   iii. the discharge flow pattern at B

SOME USEFUL EQUATIONS

$$\frac{d(uv)}{dx} = u\frac{dv}{dx} + v\frac{du}{dx}$$

$$\frac{d(\ln u)}{dx} = \frac{1}{u}\frac{du}{dx}$$

$$\frac{d(e^u)}{dx} = e^u\frac{du}{dx}$$

$$F_i = \frac{T_i^*}{T_i}$$

$$F_i^k = \frac{T_i^*}{T_i^k}$$

$$F = \frac{\sum_i T_i^*}{\sum_i T_i}$$

$$F^k = \frac{\sum_i T_i^*}{\sum_i T_i^k}$$

$$t_{ij}^1 = t_{ij}\frac{F_i F_j}{F}$$

$$t_{ij}^k = t_{ij}^{k-1}\frac{F_i^{k-1} F_j^{k-1}}{F^{k-1}}$$

$$U_{sw} = \frac{q_b - q_a}{k_b - k_a}$$

$$Q_I(t) = G_I\left[Q_I(b)\right]$$

$$R_I = \frac{Q_I(t)}{Q_I(current)}$$

$$Q_{IJ}(new) = \frac{[Q_{IJ}(current)]R_J}{\sum_x [Q_{Ix}(current)]R_x} Q_I(t)$$

$$Q_{IJ}(current) = Q_{JI}(current) = \frac{Q_{IJ}(new) + Q_{JI}(new)}{2}$$

$$P(x \perp t) = \frac{(qt)^x e^{-qt}}{x!}$$

$$c_{opt} = \frac{1.5L + 5}{(1 - \sum y_c)}$$

$$c_{\min} = \frac{L}{(1 - \sum y_c)}$$

$$C = \frac{g_e}{c} S$$

$$y_i = \frac{V}{S}$$

$$g_e = g_d - SL + EG$$

Marking Scheme

1. 4 marks each for u_m, k_m, u_f, q_m and 4 marks for graphs.
2. 4 marks for Cmin, 4 marks for Copt, 4 marks for Gi, 4 marks for delay lane 5
3. 4 marks for each description.
4. 5 marks for each part
5. 4 marks for each description
6. 4 Marks for each description
7. 5 marks for each part.