UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 5 Examination in Engineering: May 2023

Module Number: CE5306 **Module Name: Traffic and Transportation Engineering (C18)**

[Three Hours]

[Answer all questions. Each question carries **TWELVE** marks]
All Standard Notations denote their regular meanings

Q1. The most suitable method for estimating the traffic flow of a road link is the Greenshields model, which incorporates a jam density value of 120 veh/km and a free-flow speed value of 80 km/h. When traffic in this road link is moving at a steady space mean speed of 60 km/h, a heavy vehicle enters the flow of traffic and maintains a constant speed of 30 km/h for a distance of 300 meters. The heavy vehicle then abruptly reduces its speed to 20 km/h and proceeds to travel for an additional 200 meters before exiting the vehicle stream. Supposing that overtaking the heavy vehicle is not feasible for the entire 500 meter stretch, and the saturation state was achieved once the heavy vehicle exited the link; answer the following.

a) i. Determine the density of the vehicle stream before the heavy vehicle entered the vehicle stream

[1.0 Marks]

ii. Draw an annotated density flow diagram indicating all relevant states of this scenario.

[2.0 Marks]

iii. Determine all shockwave speeds

[2.0 Marks]

iv. Draw an annotated distance-time graph indicating all relevant traffic states of this scenario.

[2.0 Marks]

v. Determine the maximum length of the resulting platoon and platoon dissipation time.

[2.0 Marks]

b) A developer wants to provide access to a new building from a driveway placed 305 m upstream of a busy intersection. He is concerned that queues developing during the red phase of the signal at the intersection will block access. If the speed on the approach averages 56 km/h, the density is 50 veh/km, and the red phase is 20 sec, determine if the driveway will be affected. Assume that the traffic flow has a jam density of 110 veh/km and can be described by the Greenshields model.

[3.0 Marks]

Q2. The data presented in Table Q2-1 was gathered to calibrate the traffic flow model developed by Underwood for a specific road link. Using standard notations, the traffic flow model formulated by Underwood is expressed as follows.

$$U = U_f\left(e^{\left[\frac{-K}{K_0}\right]}\right)$$

a) i. Use the least square error method to obtain equations that calculate the intersection and slope of a linear equation.

[3.0 Marks]

ii. Utilize the aforementioned equations (in Q2. A) i.) to ascertain suitable values for K_0 and U_f.

[2.0 Marks]

iii. Calculate the highest possible flow rate and the density at which it transpires for the calibrated model.

[2.0 Marks]

b) For a duration of one hour, there is a sudden surge in the volume of vehicles at an intersection approach. The influx of vehicles during this hour is 1,900 veh/h. The intersection approach has a capacity of 1,200 veh/hg and is regulated by a signal with a cycle length of 120 seconds and a green duration of 55 seconds.

i. Using calculations, identify the type of delay encountered by the intersection approach.

[1.0 Marks]

ii. Calculate the mean control delay for each vehicle over the entire hour.

[2.0 Marks]

iii. Calculate the mean control delay for each vehicle during the initial and concluding 15 minute intervals of the hour.

[2.0 Marks]

Q3 a) List and provide concise definitions for the three categories of traffic control devices, provide a sample illustration for each type and specify the associated colour scheme.

[3.0 Marks]

b) The traffic signal design process involves evaluating the turning movement counts depicted in Figure Q3-1. Respond to the subsequent questions and provide any underlying assumptions clearly.

i. Check for the right turns that need protection.

[1.0 Marks]

ii. Draw the phase diagram.

[1.0 Marks]

iii. Using Table Q3-1 convert volumes to through-vehicle equivalents.

[2.0 Marks]

iv. Determine the critical volumes for each phase by drawing a ring diagram.

[2.0 marks]

v. Assuming an amber time of 4 s and all red time of 3 s determine the total lost time per phase.

[1.0 Marks]

vi. Determine the desired cycle length.

[2.0 Marks]

Q4 The traffic expansion method employs well-established long-term master count stations to determine the required traffic flows at specific locations.

a) State an advantage and a disadvantage of the count expansions method.

[1.0 Marks]

b) Table Q4-1 and Table Q4-2 exhibit the findings of a long-term survey on traffic volume counts conducted on a link in front of a private hospital. Compute the daily and monthly expansion factors for this site using the available data.

[2.0 Marks]

c) Since long-term traffic volume count surveys are not accessible for links situated in front of three proposed hospitals named 'B', 'C', and 'D', it was determined that the long-term data acquired in Q4.b) would be utilized as the primary source for other proposed hospitals. One-hour counts were done at the proposed developments 'B', 'C', and 'D'. Assuming the hourly expansion factor for 2:00 to 3:00 pm to be 10.420 and using the data shown in Table Q4- 3 determine the AADTs at links in front of three proposed hospitals 'B', 'C', and 'D'.

[5.0 Marks]

d) A study is required to identify the route taken by cricket stadium attendees. Develop a plan to record the movement of a representative sample of spectators.

[2.0 Marks]

e) Explain the working principles of ATC.

[2.0 Marks]

Q5. a) Share auto-rickshaws are a common means of public transportation in major cities of Tamil Nadu, India. Explain the working principles of share auto-rickshaws.

[2.0 Marks]

b) Compare and contrast the essential features of LRT and MRT systems.

[2.0 Marks]

c) Using a graph that illustrates transport density versus distance, compare and contrast the bus and monorail modes of transportation.

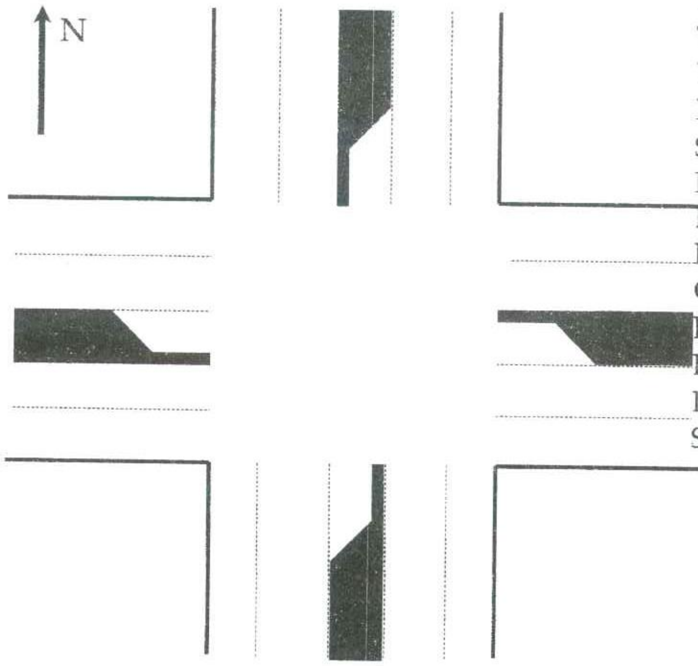
[4.0 Marks]

d) Describe how the implementation of bus rapid transit (BRT) can address four problems that currently exist within Sri Lanka's bus transportation system.

[4.0 Marks]

Table Q2-1 Space mean speed and density of a road section

Density (Veh/km)	Space mean speed (km/h)
20	67.0
25	60.7
30	54.9
35	49.7
40	44.9
45	40.7
50	36.8
60	30.1
70	24.7
80	20.2



PHF = 0.80
Target (v/c) ratio=0.85
Driver reaction time = 2 s
Pedestrian walking speed = 1.2 m/s
Speed limit (all approaches) = 70 km/h
Moderate pedestrian volumes
Level grades
Deceleration rate= 3 m/s²
Crosswalk width= 3.6 m
Driver Encroachment =3s
Default l_1= 3s
Default e= 3s
Saturation Flowrate-2500 veh/hg

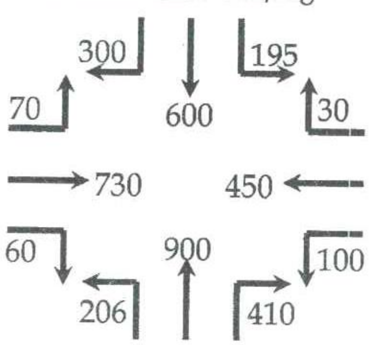


Figure Q3-1 Traffic Flow Details of an Intersection

Table Q3-1

Approach	*Movement*	*Volume (Veh/h)*	E_{RT} *or* E_{LT}	*Volume (tvu/h)*	*Lane group vol (tvu/h)*	*Vol/Lane (tvu/h)*
EB	R					
	T					
	L					
WB	R					
	T					
	L					
NB	R					
	T					
	L					
SB	R					
	T					
	L					

Table Q3-2 Adjustment for Right Turn Equivalence (TRB) E_{RT}

Opposing through plus left flows (vph)	Number of Lanes		
	1	2	3
0 – 199	1.1	1.1	1.1
200 – 399	2.5	2.0	1.8
400 – 599	5.0	3.0	2.5
600 – 799	10.0	5.0	4.0
800-999	13.0	8.0	6.0
1000-1199	15.0	13.0	10.0
≥1200	15.0	15.0	15.0
Adjustment for Right Turn Equivalence with protection = 1.05			

Table Q3-3 Left turning multiplicative factors for Pedestrians movementsE_{LT}

Pedestrian flow per hour	Multiplicative Factor
None (0)	1.18
Low (50)	1.21
Moderate (200)	1.32
High (400)	1.52
Extreme (800)	2.14

Table Q4-1 AADT by day of a link in front of hospital

Day of the week	**AADT for the Day (Veh/Day)**
Monday	25,916
Tuesday	27,873
Wednesday	26,077
Thursday	27,384
Friday	29,506
Saturday	18,884
Sunday	9,483

Table Q4-2 AADT by month of a link in front of hospital

Month	AADT of Monthly (Veh/Day)
January	26,741
February	29,475
March	20,423
April	28,080
May	22,155
June	24,752
July	19,740
August	15,619
September	19,507
October	19,551
November	24,149
December	26,747

Table Q4-3 Traffic Flow Details of a link in front of School

Hospital	Day	Month	Traffic Volume (Veh/hour)
B	Monday	November	890
C	Tuesday	December	430
D	Wednesday	December	665

Equations

$$a = \frac{1}{n}\sum_{i=1}^{n} y_i - \frac{b}{n}\sum_{i=1}^{n} x_i = \bar{y} - b\,\bar{x}$$

$$b = \frac{\sum_{i=1}^{n} x_i y_i - \frac{1}{n}(\sum_{i=1}^{n} x_i)(\sum_{i=1}^{n} y_i)}{\sum_{i=1}^{n} x_i^2 - \frac{1}{n}(\sum_{i=1}^{n} x_i)^2}$$

$$R^2 = \frac{\sum_{i=1}^{n}(Y_i - \bar{y})^2}{\sum_{i=1}^{n}(y_i - \bar{y})^2}$$

$$C_{des} = \frac{L}{1-\sum_{i=1}^{p}\left(\frac{Y_i}{PHF\times\left(\frac{v}{c}\right)}\right)}$$

$$g_i = \frac{q_{ci}}{q_c} \times (C_{des} - L)$$

$$ar = \frac{P+L_v}{1.47\times S_{85}}$$

$$q_{LT} \geq 200 \text{ veh/h}$$

$$q_{LT} \times \left(\frac{q_O}{N_O}\right) \geq 50{,}000$$

$$N = \left(\frac{Z_C\times\sigma}{E}\right)^2$$

$$\bar{T_S} = T_S + \frac{O_S - P_S}{V_S}$$

$$V_N = \frac{N_S+O_N-P_N}{T_N+T_S}$$

$$\frac{\Delta t_1}{\Delta t-\Delta t} = \frac{m-p}{q-p}$$

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

$$P(h \geq t) = e^{-\lambda(t-\tau)}$$

$$UD_o = 0.5C\left[1 - \frac{g}{C}\right]$$

$$OD = \frac{T_1+T_2}{2} \times (X - 1)$$

$$UD = \frac{C}{2}\frac{\left[1-\left(\frac{g_i}{C}\right)\right]^2}{\left[1-\frac{q}{s}\right]}$$

$$q = U_f \times k - \frac{U_f}{k_j} \times k^2$$

$$q = c \times k \times \ln\left[\frac{k_j}{k}\right]$$

$$U = U_f - \frac{U_f}{k_j} \times k$$

$$U = c \times \ln\left[\frac{k_j}{k}\right]$$

$$L = \lambda \times W$$

$$L_q = \lambda \times W_q$$

$$W = W_q + \frac{1}{\mu}$$

$$L - L_q = \rho$$

$$\rho = \frac{\lambda}{\mu}$$

$$c = S \times \frac{g}{C}$$

$$DEF = \frac{\text{Average total volume for week}}{\text{Average volume for particular day}}$$

$$MEF = \frac{AADT}{\text{ADT for particular month}}$$

$$HEF = \frac{\text{Total volume for 24hr period}}{\text{Volume for particular hour}}$$