# UNIVERSITY OF RUHUNA

## Faculty of Engineering

End-Semester 5 Examination in Engineering: March 2022

**Module Number: CE5306** **Module Name: Traffic and Transportation Engineering (C-18)**

**[Three Hours]**

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

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Q1. Traffic flow of a link is given by $U = U_f\left(1 - \frac{K}{K_j}\right)$, where jam density is 150 veh/km and free-flowed is 100 km/h. When the traffic in this link is moving at a steady space mean speed of 60 km/h, a heavy vehicle joins the traffic and moves at a steady speed of 30 km/h after travelling for 600 m it leaves the vehicle stream. It is impossible to overtake the heavy vehicle during the entire 500 m distance. After the heavy vehicle left the vehicle stream initially moves with saturation condition later the link returned to the original state.

a) i. Determine the density and the flow rate of the vehicle stream before and after the heavy vehicle joined the stream.

[2.0 Marks]

ii. Draw a density, flow curve and indicate all relevant states and shockwave speeds applicable to this scenario.

[1.0 Marks]

iii. Determine all related shockwave speeds

[3.0 Marks]

iv. Draw distance-time graph indicating all states and shockwave speeds

[2.0 Marks]

v. Determine the maximum platoon, the furthest point of platoon and platoon dissipation time.

[2.0 Marks]

b) The traffic flow on a highway link is 2000 veh/hr with a space mean speed of 80 km/hr. As a result of an accident, the road is completely blocked. A que is formed at the back of the accident. The jam density in the queue is 275 veh/km. Determine the speed of the queue formation.

[2.0 Marks]

Q2. Underwood made developments to the existing traffic models by introducing a new parameter ($n$) to provide for a more generalised modelling approach. Underwoods proposed a model in usual notations is shown below.

$$U = U_f e^{\frac{-k}{k_o}}$$

Table Q2-1 shows the data gathered to calibrate the model

a) i. Linearise the equation Underwoods model in the form of $y = a + bx$ using a log transformation

[2.0 Marks]

ii. By graphical or any other method determine the appropriate values of $K_o$ and $U_f$.

[3.0 Marks]

iii. Determine the maximum flow rate and the density at which the maximum flowrate occurs

[3.0 Marks]

b) An approach of an intersection experiences a sudden increase in vehicle flow rate for one hour period. During this time, vehicles arrive at a rate of 1,900 veh/h. If the capacity of the intersection approach is 1100 veh/hg and has a signal with a cycle length of 120 s and a green time of 55 seconds, determine the following

i. type of delay experienced by the approach;

ii. average control delay per vehicle for the full hour;

iii. average control delay per vehicle for the first and the last 15 minutes periods of the peak period.

[4.0 Marks]

Q3. a) It is required to install traffic control devices inside the Hambantota harbour premises (walled private premises). Name, briefly define the three types of traffic control devices, sketch one typical example for each type and indicate colour scheme (no need to colour).

[3.0 Marks]

b) Based on the turning movement counts of an intersection (see Figure Q3-1) stating any assumptions clearly answer the following questions.

i. Check for the right turns that need protection.

ii. Draw the phase diagram.

iii. Convert volumes to through vehicle equivalents (**Use Table Q3-1 on page no 7 of 8**).

[6.0 Marks]

c) Determine the critical volumes for each phase by drawing the ring diagram.

[2.0 marks]

d) Draw the traffic conflict diagram for the case provided in **Figure Q3-2 on page number 8 of 8.**

[1.0 Marks]

Q4. a) A short-time count at station 1 made on Tuesday showed a total of 420 vehicles entering from 9:00 am to 9:30 am, and 500 vehicles entering between 2:00 pm to 2:30 pm. Estimate the 12-hour flow (weekly average) at station 1, if the 12-hour counts at station "A" (the master station) made on same Tuesday showed 9,560 vehicles and if station "A" recorded the volumes of 410 vehicles between 9:00-9:30 am and 356 vehicles between 2:00-2:30 pm.

[3.0 Marks]

b) Data obtained in a long-term traffic volume count survey at a link in front of a private hospital 'A' is shown in Table Q4-1 and Table Q4-2. Determine the daily expansion factors and the monthly expansion factors for this location.

[3.0 Marks]

c) Due to the non-availability of long-term traffic volume count surveys at links in front of three proposed developments 'B', 'C' and 'D', it was decided to use the long-term data obtained in Q4.c) as the master station for other proposed hospitals. One-hour counts were done at the proposed developments 'B', 'C' and 'D'. Assuming the hourly expansion factor 2:00-3:00 pm to be 14.320 and using the data shown in Table Q4-3 determine the AADTs at links in front of three proposed hospitals 'B', 'C' and 'D'.

[6.0 Marks]

Q5. a) Explain the working principles of "Share auto-rickshaws" used in Tamil Nadu, India.

[3.0 Marks]

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

[3.0 Marks]

c) Identify three issues in the public bus transportation in Sri Lanka

[3.0 Marks]

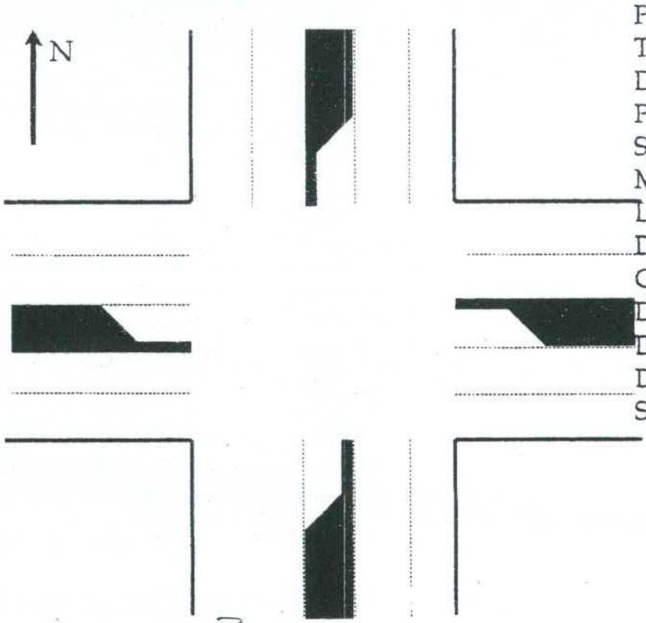
d) Explain the working principle of Automated people mover giving advantages and disadvantages.

[3.0 Marks]

## Tables and Figures

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

| Density (Veh/km) | Space mean speed (km/h) |
|---|---|
| 10 | 88.2 |
| 20 | 77.9 |
| 30 | 68.7 |
| 40 | 60.7 |
| 50 | 53.5 |
| 60 | 47.2 |
| 70 | 41.7 |
| 80 | 36.8 |
| 90 | 32.5 |
| 100 | 28.7 |
| 120 | 22.3 |




PHF = 0.92
Target (v/c) ratio=0.90
Driver reaction time = 1 s
Pedestrian walking speed = 1.1 m/s
Speed limit (all approaches) = 60 km/h
Moderate pedestrian volumes
Level grades
Deceleration rate= 3 m/s$^2$
Cross walk width= 3.3 m
Driver Encroachment =2s
Default $l_1$= 2s
Default e= 2s
Saturation Flowrate-1615 veh/hg

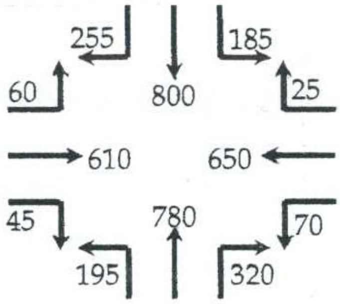



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Figure Q3-1 Traffic Flow Details of an Intersection

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 movements$E_{LT}$

| 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 'A'

| 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 'A'

| 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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$L = \lambda \times W$$

$$L_q = \lambda \times W_q$$

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

$$L - L_q = \rho$$

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

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

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

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

**(NOTE: Detach Table Q3-1 and Figure Q3-2 attach it to answer script)**

**Index number: ..........................................**

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 | | | | | |

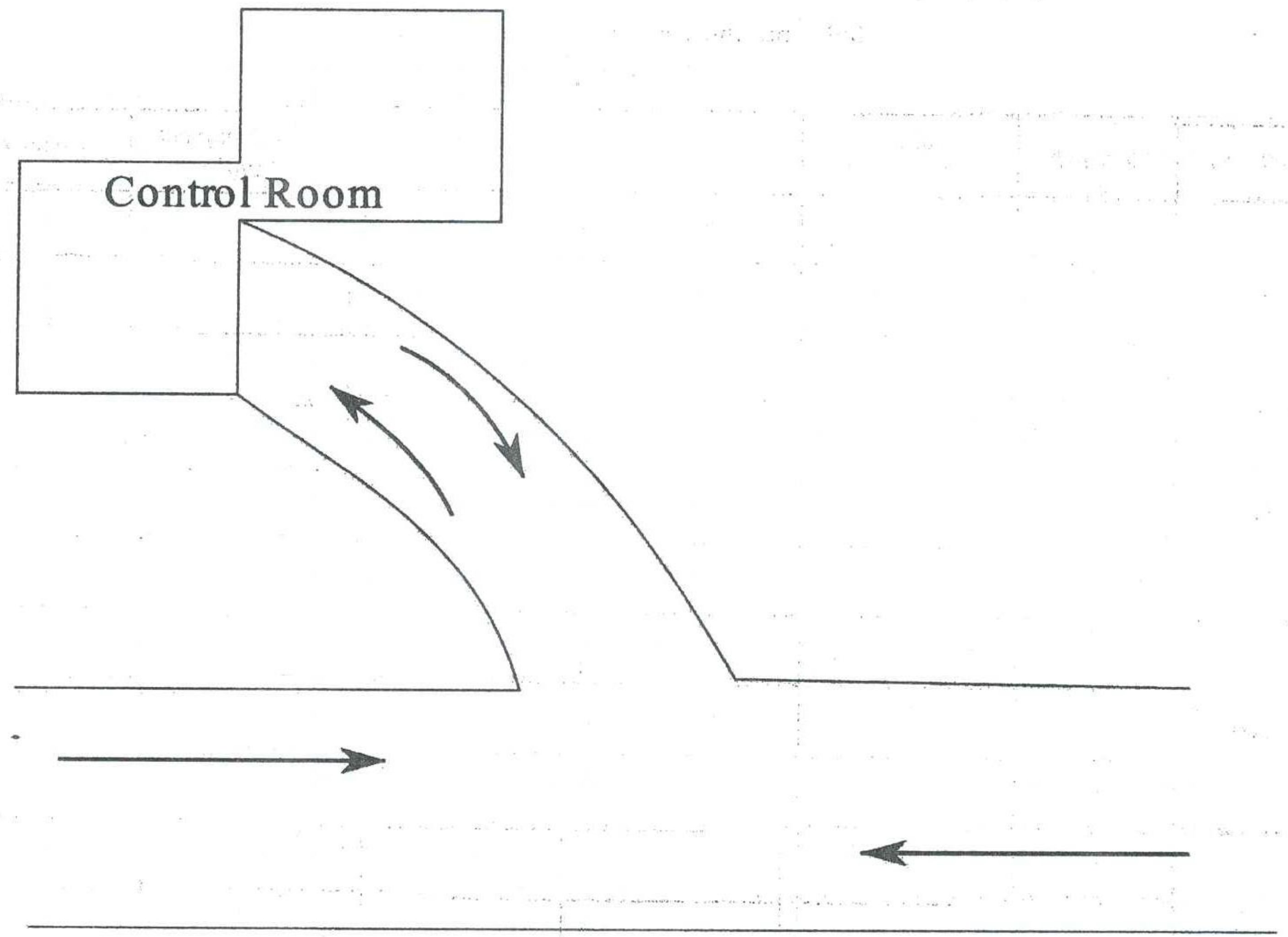


Figure Q3-2 Traffic Conflict Diagram