UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 4 Examination in Engineering: December 2015

Module Number: CE4304 **Module Name: Transportation Engineering**

[Three Hours]

[Answer all questions. Each question carries **TWELVE** marks]
All Standard Notations denote their regular meanings. You may assume values for any needed parameter with justification

---

Q1. Galle Municipal council wants to develop the transportation system in Galle Municipal area into a sustainable and effective system. Project is termed as Galle MC Sustainable Transportation System Development (GASTRASD) As the only transportation Engineer in the team appointed for this purpose, answer the following questions.

a) GASTRASD team is undecided on what sustainable transportation is, define the term sustainable transportation for the GASTRASD team.

[2.0 Marks]

b) Sustainable transportation development has many facets. Briefly explain three of them which GASTRASD team has to look into.

[3.0 Marks]

c) Move to alternative sustainable fuels was suggested by one of the team members. List three possible sustainable fuels for vehicles and their sources.

[3.0 Marks]

d) "Three Wheeler Electrification" was proposed as a sub-project under the GASTRASD. Give two reasons each to accept this sub-project and to reject this sub-project. Consider only environmental reasons.

[4.0 Marks]

Q2. As the first part of the GASTRASD project described in Q1, many traffic surveys are to be conducted in Galle MC area.

a) Journey time to four main intersections of Galle MC area from Galle central market is needed. GASTRASD team leader wants Journey times for every hour of the day based on data collected for 3 months. Explain the procedure you would adopt to collect data.

[3.0 Marks]

b) In order to inform the public about GASTRASD, especially people coming to Galle from outside, GASTRASD team wants to put up some posters in Galle International Cricket Stadium. To find the optimum place for the posters, path of public inside the stadium is need to be known. Explain how would you carryout this survey.

[3.0 Marks]

c) Data given in Table Q2-1 and Table Q2-2 shows that data obtained from a traffic count survey using ATC at a link in front of a leading school in Galle MC area. Using the data calculate the daily Adjustment factors for the 7 days of the week and the monthly adjustment factor for the 12 months.

[3.0 Marks]

d) Due to limited number of ATCs with GASTRASD project it was decided to use the data location in Q2.c) as the master station for all other schools in Galle MC. One day counts were done at all other schools except the master station. Using the data shown in Table Q2-3 determine the AADT in front of schools in Galle MC.

[3.0 Marks]

Q3. a) As part of the GASTRASD project Several intersections are to be signalised. Turning movement count details and relevant data at such an intersection in Galle MC area is shown in Figure Q3-1. Answer the following questions based on data provided (you may use Table Q3-2 and Table Q3-3).

I. Check for the right-turns that need protection.
II. Draw the phase diagram
III. Convert volumes to through vehicle equivalents (Use the Table Q3-1)

[6.0 Marks]

b) Determine the critical volumes for each phase.

[2.0 marks]

c) Assuming a Amber time of 3 s and All red time of 3 s determine the total lost time per phase.

[1.0 Mark]

d) Determine the total desirable cycle length and the effective green time for each phase.

[2.0 Marks]

e) Explain the term traffic signal coordination.

[1.0 Mark]

Q4. From Galle bus stand Minuwangoda Junction can be reached by three routes, route **A**, route **B** and route **C** all routes have 2 lanes. The traffic along route **A** can be approximated by Greensburg's model while traffic in route **B** and **C** follows Greenshield's model. Route B has free flow speed of 100 km/h and the jam density of 150 vehicles per km per lane. Route C has a free flow speed of 60 km/h and the jam density of 100 vehicles per km per lane. At present, during morning peak hour route A carries a flow rate of 2372 veh/h at 39.54 veh/km density, route B carries 1800 veh/h at 30 veh/km and route C carries 765veh/h at 15 veh/km.

As part of the GASTRASD project it was decided to introduce a one-way scheme. According to the new one-way scheme route A will carry the traffic in to Galle while Routes B and C will carry traffic from Galle.

a) Due to recent renovations by As part of the GASTRASD project in route A, it is necessary to re-calibrate the Greensburg's model for route A. Calibrate the Greensburg's model using the data given in Table Q4-1. Hence find the speed at the maximum flow condition and Jam density.

[4.0 Marks]

b) If the Route A operates as a non-congested flow, determine the flow rate, space mean speed and density of vehicles per lane in route "A" after one-way scheme is introduced.

[3.0 Marks]

c) After the implementation of one-way scheme if routes B and C will operate so that the travel time in the routes A and B are same. Assuming that the Routes B and C are of same length (0.75 km) and Route B is operates as "a congested flow" calculate the following.

I. Densities on routes B and C
II. Flow rates on routes B and C
III. Travel time out of the town to Minuwangoda.

[5.0 Marks]

Q5. a) Traffic on the eastbound approach of a signalized intersection is travelling at 65 km/h, with a density of 27 veh/km/ln. The duration of the red signal indication for this approach is 30 sec. If the saturation flow is 19500 veh/h/ln with a density of 32 veh/km/ln, and the jam density is 75 veh/km/ln, determine the following:

I. The length of the queue at the end of the red phase
II. The maximum queue length
III. The time it takes for the queue to dissipate after the end of the red indication.

[6.0 Marks]

b) Traffic flow on a section of a two-lane highway can be described by the Greenshield's model, with a mean free speed of 90 km/h and a jam density of 90 veh/km/ln. At the time when the flow was 90% of the capacity of the highway, a large dump truck loaded with heavy industrial machinery from an adjacent construction site joins the traffic stream and travels at a speed of 25 km/h for a length of 5.5 km along the upgrade before turning off onto a dump site. Due to the relatively high flow in the opposite direction, it is impossible for any car to pass the truck.

I. Determine the length of queue at the end of red phase
II. Determine how many vehicles will be in the platoon behind the truck by the time the truck leaves the highway.

[6.0 Marks]

Table Q2-1 Traffic Flow Details of a link in front of School

Day of the week	Yearly Average Daily Volume for the Day (Veh/Day)
Monday	1,820
Tuesday	1,588
Wednesday	1,406
Thursday	1,300
Friday	1,289
Saturday	1,275
Sunday	1,332

Table Q2-2 Traffic Flow Details of a link in front of School

Month	Total Volume (Veh)
January	19,840
February	16,660
March	21,235
April	24,300
May	25,885
June	26,280
July	27,652
August	30,008
September	28,620
October	26,350
November	22,290
December	21,731

Table Q2-3 Traffic Flow Details of a link in front of School

School Name	Day	Month	Total Volume (Veh/day)
School 1	Monday	March	1,100
School 2	Tuesday	March	1,230
School 3	Wednesday	March	975
School 4	Thursday	March	800
School 5	Friday	March	1,000

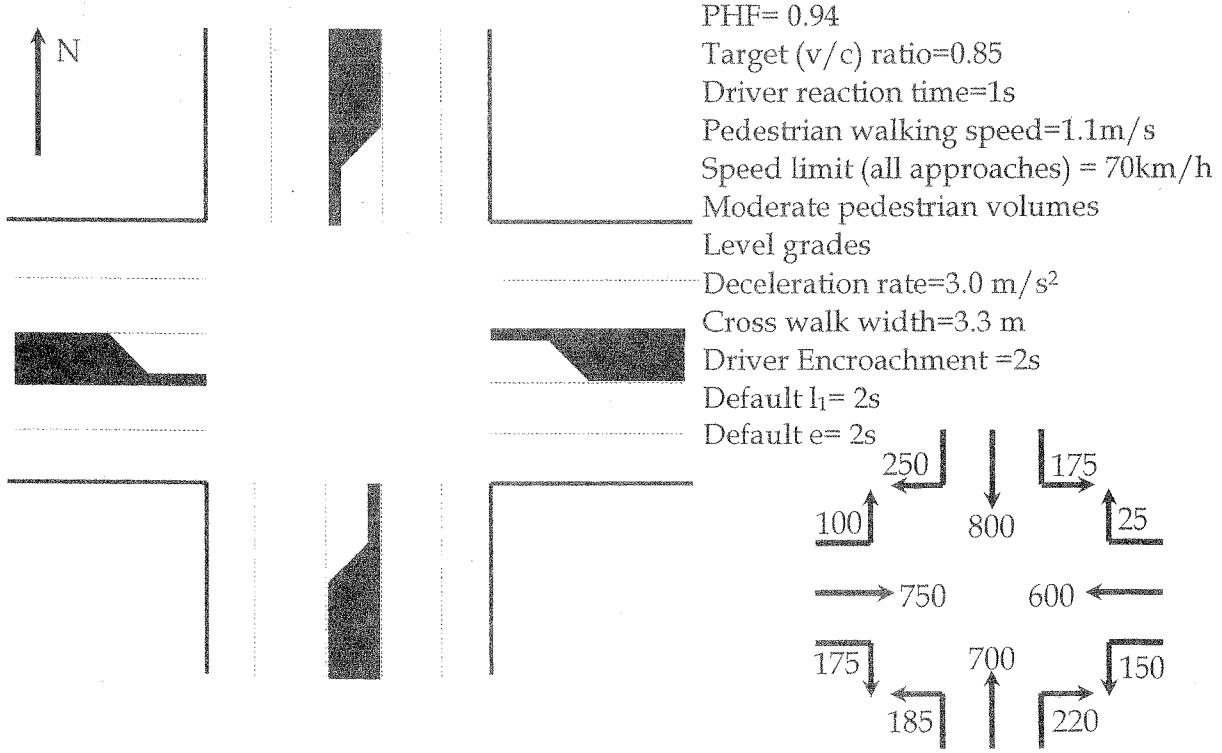

Figure Q3-1 Traffic Flow Details of an Intersection

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
1,000-1,199	15.0	13.0	10.0
≥1,200	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 Speed and density data

Density (veh/km/lane)	**Space Mean Speed (kmph)**
30.0	72.42
40.0	59.48
55.5	44.74
65.0	37.63
70.0	34.30
85.5	25.30
91.0	22.49
95.0	20.55
110.0	13.96
112.0	13.15
135.0	4.74
133.0	5.41
67.0	36.27
89.0	23.49

Equations

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

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

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

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

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

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

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

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

Table for Signal Calculations 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					