UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 5 Examination in Engineering: August 2014

Module Number: CE5315 **Module Name: Transportation Engineering**

[Three Hours]

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

Q1. a) Name and briefly define the three distinct components of delay.

[1.5 Marks]

b) Derive the equation for uniform delay in the following form, starting from basics and clearly stating the conditions assumed.

$$UD = \frac{0.5 \times C \times (1 - g/C)^2}{(1 - X \times g/C)}$$

And show that the uniform delay has a maximum value when flow rate reaches capacity.

[2.0 Marks]

c) West bound arm of the Nupe intersection at off-peak hours has traffic flow-rate of 1,200 veh/h. The saturation flow rate for the approach is estimated to be 3,250 veh/hg, with a 100 s cycle length, and 55 s of effective green. Determine the delay of vehicles during the off-peak period.

[3.0 Marks]

d) The same west bound arm (in section c) of the Nupe intersection experiences chronic oversaturation for a one-hour period each day. During this time, vehicles arrive at a rate of 2,500 veh/h. The saturation flow rate for the approach is 3,250 veh/hg, with a 100 s cycle length, and 55 s of effective green.
What is the average control delay per vehicle for the full hour?

i) What is the average control delay per vehicle for the first 15 minutes of the peak period?

ii) What is the average control delay per vehicle for the last 15 minutes of the peak hour?

[5.5 Marks]

Q2. a) Using figures and equations where appropriate, define the following terms in the context of traffic signal design.

i. Clearance lost time
ii. Start-up lost time
iii. Saturation headway
iv. All red interval

[2.0 Marks]

b) Signal system used in the Nupe intersection has a three phases and a cycle length of 100 s. East-west direction (1 lane per direction) flow has a green time of 52 s, amber time of 5 s, all-red time of 3 s and a total lost time of 5 s. If a saturation headway of 1.11 s can be assumed for the mix of traffic at the intersection. Calculate the capacity of a west bound-lane group.

[2.0 Marks]

c) Starting from the first principles, derive the equation for the minimum cycle length of a traffic signal, in terms of maximum sum of critical lane volumes, saturation flow, number of phases in a cycle, and total losses per phase.

[3.0 Marks]

d) If the future maximum sum of critical flow at Nupe intersection is estimated to be 2,200 veh/h, assuming that the signal system remains as 3 phase system with 5 s loss time/phase, and a saturation flow rate of 3400 veh/hg determine the minimum cycle length required.

[1.0 Marks]

e) During a separate study at the signalized Nupe intersection, one lane is observed to discharge 18 through vehicles in the same time as the right lane discharges 9 through vehicles and 3 right-turning vehicles. For this case:

i) What is the through-vehicle equivalent, E_{RT},

ii) If right turns amount is 10% of the flow, determine the right-turn adjustment factor, f_{RT}

iii) What variables may affect the observed value of E_{RT}?

[4.0 Marks]

Q3. a) A supermarket complex in a Galle has requested a proposal for improving the parking facilities for customers. The existing parking facility is provided with two gates for 'in' and 'out' facing a main street. The following conditions have been included in the TOR.

1. Identification of parking demand during each hour.
2. Identification of peak hours.
3. Estimation of parking slot demand.
4. Estimation of average parking duration of vehicles

What types of surveys could be recommended for this study? Explain the expected outcome of the surveys.

[3.0 Marks]

b) What are the details to be included in the survey form to be provided with the proposal?

[3.0 Marks]

c) What are the resources needed to conduct the surveys in relation to the following?

i) Number of enumerators.
ii) Equipment.
iii) Survey locations.

[3.0 Marks]

d) Briefly explain how the data may be analysed to obtain the requested TOR items (1-4) mentioned above.

[3.0 Marks]

Q4. a) The data in Table Q4 were obtained in a travel time study on a 2 km section of highway using the moving-vehicle technique. Determine the travel time and volume in each direction at this section of the highway.

[5.0 Marks]

b) Cricket Sri Lanka wants to know the paths taken by viewers and places they sit etc. during an International match at the Galle International Cricket Stadium for better placements of advertisements and notices. Give details of a study you would undertake to fulfil this requirement.

[4.0 Marks]

c) Galle Municipal council wants to know the travel times between major centres in Galle MC area. Describe 2 study methods that can fulfil this need.

[3.0 Marks]

Q5. a) Using the data given in the Table Q5, determine the following;

i) Average speed
ii) Standard deviation of the speed
iii) Standard error of the speed
iv) 80% Confident interval of the speed
v) What is confidence that the mean is 60 km/h

[7.0 Marks]

b) Explain in detail the terms BRT and MRT especially giving consideration to Sri Lankan context.

[5.0 Marks]

Table Q4: Data from Travel Time Study Using the Moving-Vehicle Technique

Run Direction/Number	Travel Time (min)	No. of Vehicles Travelling in Opposite Direction	Overtook Test Vehicle	Overtaken by Test Vehicle
Eastward				
1	2.75	80	1	1
2	2.55	75	2	1
3	2.85	83	0	3
4	3.00	78	0	1
5	3.05	81	3	4
6	2.70	79	3	2
7	2.82	82	1	1
8	3.08	78	0	2
Westward				
1	2.95	78	2	3
2	3.15	83	2	1
3	3.20	89	3	3
4	2.83	86	3	0
5	3.30	80	2	1
6	3.00	79	1	2
7	3.22	82	2	1
8	2.91	81	0	1

Table Q5 Speed Distribution along Faculty access road

Lower limit	*Upper limit*	*Frequency Observed* (n_i)
34	35.9	4
36	37.9	5
38	39.9	6
40	41.9	5
42	43.9	3
44	45.9	6
46	47.9	4
48	49.9	25
50	51.9	20
52	53.9	15
54	55.9	11
56	57.9	5
58	59.9	2
60	61.9	4
62	63.9	1
64	65.9	0

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

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

$$\bar{X} = \frac{\sum_{i=1}^{K} n_i X_i}{N}$$

$$S = \sqrt{\frac{N\sum_{i=1}^{K} n_i {X_i}^2 - (\sum_{i=1}^{K} n_i X_i)^2}{N(N-1)}}$$

$$S_M = \frac{S}{\sqrt{N}}$$

$$\bar{X} - Z_{\alpha/2}S_M < \mu < \bar{X} + Z_{\alpha/2}S_M$$

Standard Normal Probabilities

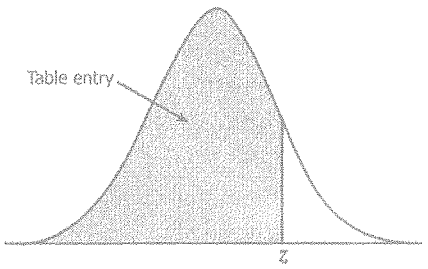

Table entry for z is the area under the standard normal curve to the left of z.

z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	.5000	.5040	.5080	.5120	.5160	.5199	.5239	.5279	.5319	.5359
0.1	.5398	.5438	.5478	.5517	.5557	.5596	.5636	.5675	.5714	.5753
0.2	.5793	.5832	.5871	.5910	.5948	.5987	.6026	.6064	.6103	.6141
0.3	.6179	.6217	.6255	.6293	.6331	.6368	.6406	.6443	.6480	.6517
0.4	.6554	.6591	.6628	.6664	.6700	.6736	.6772	.6808	.6844	.6879
0.5	.6915	.6950	.6985	.7019	.7054	.7088	.7123	.7157	.7190	.7224
0.6	.7257	.7291	.7324	.7357	.7389	.7422	.7454	.7486	.7517	.7549
0.7	.7580	.7611	.7642	.7673	.7704	.7734	.7764	.7794	.7823	.7852
0.8	.7881	.7910	.7939	.7967	.7995	.8023	.8051	.8078	.8106	.8133
0.9	.8159	.8186	.8212	.8238	.8264	.8289	.8315	.8340	.8365	.8389
1.0	.8413	.8438	.8461	.8485	.8508	.8531	.8554	.8577	.8599	.8621
1.1	.8643	.8665	.8686	.8708	.8729	.8749	.8770	.8790	.8810	.8830
1.2	.8849	.8869	.8888	.8907	.8925	.8944	.8962	.8980	.8997	.9015
1.3	.9032	.9049	.9066	.9082	.9099	.9115	.9131	.9147	.9162	.9177
1.4	.9192	.9207	.9222	.9236	.9251	.9265	.9279	.9292	.9306	.9319
1.5	.9332	.9345	.9357	.9370	.9382	.9394	.9406	.9418	.9429	.9441
1.6	.9452	.9463	.9474	.9484	.9495	.9505	.9515	.9525	.9535	.9545
1.7	.9554	.9564	.9573	.9582	.9591	.9599	.9608	.9616	.9625	.9633
1.8	.9641	.9649	.9656	.9664	.9671	.9678	.9686	.9693	.9699	.9706
1.9	.9713	.9719	.9726	.9732	.9738	.9744	.9750	.9756	.9761	.9767
2.0	.9772	.9778	.9783	.9788	.9793	.9798	.9803	.9808	.9812	.9817
2.1	.9821	.9826	.9830	.9834	.9838	.9842	.9846	.9850	.9854	.9857
2.2	.9861	.9864	.9868	.9871	.9875	.9878	.9881	.9884	.9887	.9890
2.3	.9893	.9896	.9898	.9901	.9904	.9906	.9909	.9911	.9913	.9916
2.4	.9918	.9920	.9922	.9925	.9927	.9929	.9931	.9932	.9934	.9936
2.5	.9938	.9940	.9941	.9943	.9945	.9946	.9948	.9949	.9951	.9952
2.6	.9953	.9955	.9956	.9957	.9959	.9960	.9961	.9962	.9963	.9964
2.7	.9965	.9966	.9967	.9968	.9969	.9970	.9971	.9972	.9973	.9974
2.8	.9974	.9975	.9976	.9977	.9977	.9978	.9979	.9979	.9980	.9981
2.9	.9981	.9982	.9982	.9983	.9984	.9984	.9985	.9985	.9986	.9986
3.0	.9987	.9987	.9987	.9988	.9988	.9989	.9989	.9989	.9990	.9990
3.1	.9990	.9991	.9991	.9991	.9992	.9992	.9992	.9992	.9993	.9993
3.2	.9993	.9993	.9994	.9994	.9994	.9994	.9994	.9995	.9995	.9995
3.3	.9995	.9995	.9995	.9996	.9996	.9996	.9996	.9996	.9996	.9997
3.4	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9998