UNIVERSITI SAINS MALAYSIA

1st. Semester Examination
2000/2001 Academic Session

SEPTEMBER / OCTOBER 2000

EAL231/3 – Transportation & Traffic Engineering

Time : [3 hours]

Instruction to candidates:-

1. This paper consists of **SEVEN (7)** questions. Answer **FIVE (5)** questions only.
2. Answers **MUST BE** written in Bahasa Malaysia.

1. Your are given the following road network and information.

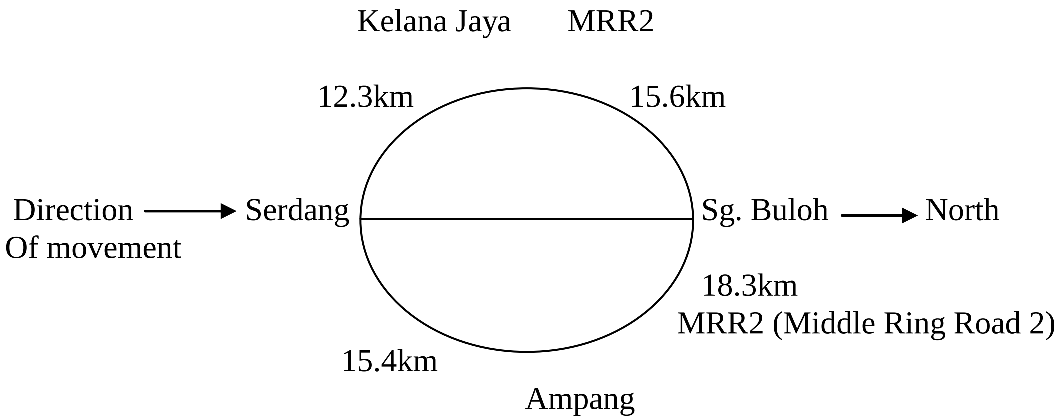


Table 1

O - D	Operated speed (km/h)	$V/_c$*	Toll (RM)	Road type
Serdang – K. Jaya	90 km/h	0.48	2.20	Expressway
Serdang – K.L.	35 km/h	2.43	-	Dual carriageway
Serdang – Ampang	80 km/h	0.75	-	Dual carriageway
K.Jaya – Sg. Buloh	65 km/h	0.54	1.50	Dual carriageway
K.L. – Sg. Buloh	55 km/h	0.89	-	Dual carriageway
Ampang – Sg. Buloh	75 km/h	0.75	-	Expressway

*Note: $V/_c$ = Volume per capacity ratio

(a) Serdang – K.L. – Sg. Buloh has been the old route to go from south to the north. With the MRR2 built and operational, travellers have new alternatives to get from Serdang to Sg. Buloh. Find the savings in generalised cost of travel for using the alternative routes and select the route with the lowest generalised cost of travel.

(10 marks)

(b) State the assumptions used to answer question (a). (5 marks)

(c) Explain the likely change in the $v/_c$ values when the public begin to use the alternative routes.

(5 marks)

2. You are required to construct a transportation model to represent the operational activities of buses, Light Rail Transit (LRT) and cars. To determine the generalised cost of travel for all three modes, you need to give values to the cost components.

(a) Indicate all of the required information. (8 marks)

(b) To acquire all the needed data requires time and cost. As a cost-effective engineer, and as a measure of cost savings, analyse all the required inputs and investigate whether the primary data acquisition can be substituted with the secondary data type and using appropriate formulae. List all the identified input and show how you intend to determine its value to be used in your model.

(12 marks)

3. (a) One stretch of two lane two way roadway that traverses through level terrain is expected to carry 1340 vehicle per hour. What is the level of service for the road if the characteristics of the roadway are as follows:

Lane width = 11 ft
Shoulder width = 5 ft
Percent no passing zone = 10 %
Peak traffic volume in one direction = 1250 veh/hr
Where, during the peak traffic volume, in one direction number of trucks = 540 and number of bus = 210. (Refer to Table 7 to Table 12 in the Appendix).

(14 marks)

(b) Observations were made at two stations XX dan YY which is located 160m apart on a stretch of roadway. Travelling time for four vehicles traversing the two stations are shown in Table 2. If the total duration of traffic observations at station XX is 17 sec, calculate:

(i) time mean speed
(ii) space mean speed
(iii) traffic flow at station XX

Table 2 : Arrival Time (A.M.)

Vehicle	Station XX	Station YY
A	8:02:15	8:02:22.58
B	8:03:14	8:03:23.18
C	8:01:18	8:01:25.36
D	8:10:25	8:10:34.74

8:00:00 = 8 Hr 00 min 00 sec

(6 marks)

4. Floating vehicle method was used to study traffic characteristics along a highway between A and B. The distance between A and B is 7.53km. Results of the study is as shown in Table 3 and Table 4.

Table 3 : Vehicles travelling from Station A to Station B

Start	Finish	Overtaking Vehicles	Overtaken Vehicles	Number of Vehicles in the opposite direction
7.02	7.15	2	4	300
7.28	7.40	3	3	360
7.50	8.07	4	2	345
8.26	8.40	5	2	410
8.50	9.00	6	3	300
9.20	9.35	1	2	340

Table 4 : Vehicles travelling from Station B to Station A

Start	Finish	Overtaking Vehicles	Overtaken Vehicles	Number of Vehicles in the opposite direction
7.18	7.25	4	4	320
7.42	7.48	3	3	350
8.10	8.24	5	5	340
8.42	8.46	2	1	330
9.02	9.18	2	2	390
9.37	9.43	3	2	365

(a) Calculate the average flow and travelling time for both directions.

(6 marks)

(b) Calculate the free flow speed and jam density for the direction from A to B.

(14 marks)

5. (a) Construction works on a roadway section causes bottleneck (closure of one lane) to the 6-lane highway (three lanes in each direction). The capacity of the road is 2450 vehicles per hour per lane. Distance between two vehicles when the traffic flow is almost stopped is 6m. When traffic flow reaches 10,430 vehicles per hour:

(i) Calculate vehicle speed in the area far away from the bottleneck.
(ii) Calculate vehicle speed near the bottleneck.

(10 marks)

5. (b) A Traffic survey was conducted during peak hour at one section of a roadway. Results of the survey for every 5 minutes are shown in Table 5.

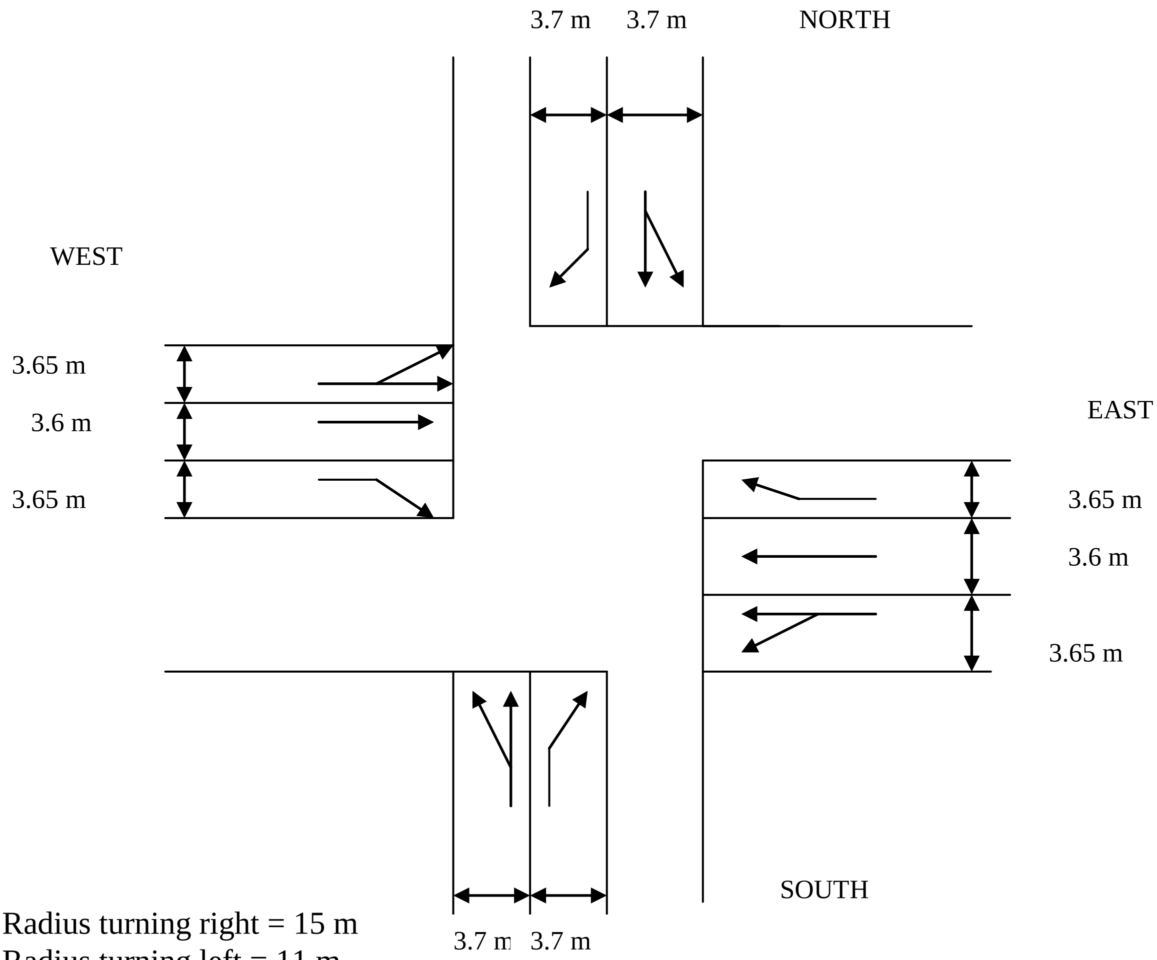
Table 5

Time	Flow (Veh/Hr)
7.30 – 7.34.9	1105
7.35-7.39.9	1145
7.40-7.44.9	1040
7.45-7.49.9	1230
7.50-7.54.9	1320
7.55-7.59.9	1603
8.00-8.04.9	1430
8.05-8.09.9	1540
8.10-8.14.9	1510
8.15-8.19.9	1220
8.20-8.24.9	1033
8.25-8.29.9	980
8.30-8.34.9	990

(i) Sketch a histogram showing the variation in traffic flow with time.
(ii) Calculate maximum flow based on a range of 15 minutes traffic flow.
(iii) Calculate average hourly traffic and when will the peak hour occur?
(iv) Estimate the peak hour factor.

(10 marks)

6. The geometric layout of a traffic light junction is shown in Figure 1.



Radius turning right = 15 m
Radius turning left = 11 m

North \ South = 0%
West \ East = 3%

Figure 1: Geometric layout of traffic light junction

Traffic volume for the junction is shown in Table 6.

a) Calculate the saturation flow for through movement and for right turning movement for the West approach.

(10 marks)

b) Calculate saturation flow for through and right turning movements for the North approach.

(5 marks)

c) Calculate the value of y for through and right turning movement for the West approach.

(5 marks)

Table 6 : Traffic Volume (veh/hr)

Approach	Vehicle Type	Right Turn	Through	Left Turn
	Car	130	450	50
	Medium Lorry	7	20	8
Timur	Heavy Vehicle	5	20	5
	Bus	0	5	2
	Motorcycle	15	100	15
	Car	120	510	45
	Medium Lorry	6	70	12
Barat	Heavy Vehicle	4	30	3
	Bus	0	10	1
	Motorcycle	20	95	20
	Car	430	220	45
	Medium Lorry	60	70	15
Selatan	Heavy Vehicle	25	30	0
	Bus	10	5	1
	Motorcycle	100	80	15
	Car	250	125	25
	Medium Lorry	50	55	12
Utara	Heavy Vehicle	20	25	1
	Bus	2	7	0
	Motorcycle	80	75	12

7. (a) Origin-Destination of roundabout junction is shown in Figure 2.

i) Calculate circulating flow and meaning flow.

ii) Based on additional data given below, calculate reserve capacity for the junction..

Diameter = 50 m.

$e = 12.8$ m
$v = 12.5$ m
$l' = 13$ m
entry radius = 33 m
entry angle = 32°

$K = 1 - 0.00347\ (\varnothing - 30) - 0.978[(1/r) - 0.05]$
$F = 303\ X_2$
$f_c = 0.21\ t_D\ (1 + 0.2\ X_2\ )$
$t_D = 1 + 0.5/\ (1 + \exp(D - 60)/10))$

$X_2 = v + (e-v) / (1 + 2 S)$
$S = 1.6(e - v) / l$

(10 marks)

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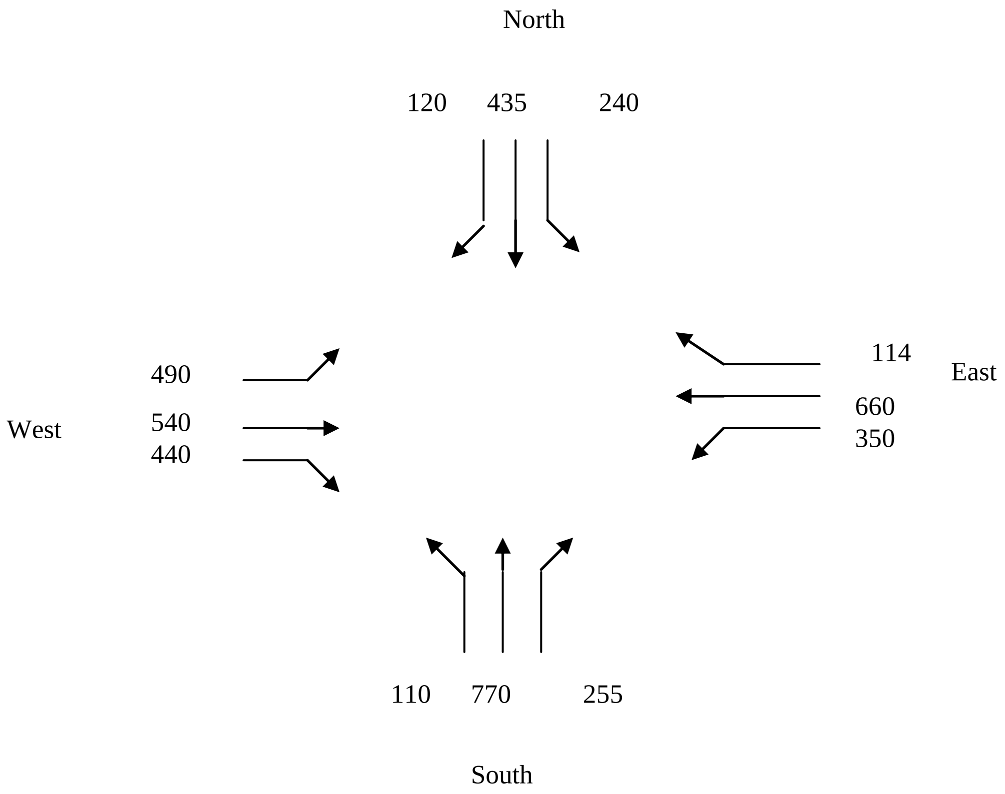

Figure 2 : Turning Volume (Veh/Hr)

(b) Discuss traffic engineering aspects that can reduce road accidents.

(10 marks)

APPENDIX

Table 7: Correction factor for directional distribution for two lane two way for level terrain.

Directional Split	Total Capacity (pc/hr)	Ratio of Capacity to Ideal Capacity (f_d)
50/50	2800	1.00
60/40	2650	0.94
70/30	2500	0.89
80/20	2300	0.83
90/10	2100	0.75
100/0	2000	0.71

Table 8: Level of service for two lane two way road (volume vs. capacity ratio)

	Percent	Level Terrain						
	Time	Avg.	Percent No Passing Zones					
LOS	Delay	Speed	0	20	40	60	80	100
A	≤ 30	≥ 58	0.15	0.12	0.09	0.07	0.05	0.04
B	≤ 45	≥ 55	0.27	0.24	0.21	0.19	0.17	0.16
C	≤ 60	≥ 52	0.43	0.39	0.36	0.34	0.33	0.32
D	≤ 75	≥ 50	0.64	0.62	0.60	0.59	0.58	0.57
E	> 75	≥ 45	1.00	1.00	1.00	1.00	1.00	1.00
F	100	< 45	-	-	-	-	-	-

Table 9 : PHF for two-lane two way road

Total 2-Way Hourly Volume (vph)	PHF	Total 2-Way Hourly Volume (vph)	PHF
100	0.83	1000	0.93
200	0.87	1100	0.94
300	0.90	1200	0.94
400	0.91	1300	0.94

500	0.91	1400	0.94
600	0.92	1500	0.95
700	0.92	1600	0.95
800	0.93	1700	0.95
900	0.93	1800	0.95
		≥ 1900	0.96

…10/-

APPENDIX

Table 10 : Correction factor for lane and shoulder width

Usable shoulder Width (ft)	12-ft Lanes		11-ft lanes		10-ft lanes		9-ft lanes	
	LOS A-D	LOS E	LOS A-D	LOS E	LOS A-D	LOS E	LOS A-D	LOS E
≥ 6	1.00	1.00	0.93	0.94	0.84	0.87	0.70	0.76
4	0.92	0.97	0.85	0.92	0.77	0.85	0.65	0.74
2	0.81	0.93	0.75	0.88	0.68	0.81	0.57	0.70
0	0.70	0.88	0.65	0.82	0.58	0.75	0.49	0.66

Table 11: Average equivalent factors for trucks, recrearional vehicles and bus for two-lane two way roads.

		Type of terrain		
Vehicle type	Level of Service	Level	Rolling	Mountainous
Trucks, E_T	A B and C D and E	2.0 2.2 2.0	4.0 5.0 5.0	7.0 10.0 12.0
RVs, E_R	A B and C D and E	2.2 2.5 1.6	3.2 3.9 3.3	5.0 5.2 5.2
Buses, E_B	A B and C D and E	1.8 2.0 1.6	3.0 3.4 2.9	5.7 6.0 6.5

Table 12 : $V/_c$ ratio for 2 lane – 2 way road on level terrain

	% no overtaking zone					
LOS	0	20	40	60	80	100
A	0.15	0.12	0.09	0.07	0.05	0.04
B	0.27	0.24	0.21	0.19	0.17	0.16

C	0.43	0.39	0.36	0.34	0.33	0.32
D	0.64	0.62	0.60	0.59	0.58	0.57
E	1.00	1.00	1.00	1.00	1.00	1.00
F	-	-	-	-	-	-

…11/-

APPENDIX

Table 13

W (m)	S (pcu/hr)
3.0	1845
3.25	1860
3.5	1885
3.75	1915
4.0	1965
4.25	2075
4.5	2210
4.75	2375
5.0	2560
5.25	2760

Table 14

Gradient	Correction Factor
+5%	0.85
+4%	0.88
+3%	0.91
+2%	0.94
+1%	0.97
0%	1.00
-1%	1.03
-2%	1.06
-3%	1.09
-4%	1.12
-5%	1.15

Table 15

Radius	Correction Factor

R < 10 m	0.85
10 m < R < 15 m	0.90
15 m < R < 30 m	0.96

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APPENDIX

Table 16

% turning volume	Right turning correction factor	Left turning correction
5	0.96	1.00
10	0.93	1.00
15	0.90	0.99
20	0.87	0.98
25	0.84	0.97
30	0.82	0.95
35	0.79	0.94
40	0.77	0.93
45	0.75	0.92
50	0.78	0.91
55	0.71	0.90
60	0.69	0.89

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