UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2023/2024

COURSE NAME	:	TRAFFIC ENGINEERING AND SAFETY
COURSE CODE	:	BFC 32302
PROGRAMME CODE	:	BFF
EXAMINATION DATE	:	JULY 2024
DURATION	:	2 HOURS
INSTRUCTIONS	:	1. ANSWER **ALL** QUESTIONS FROM **PART A** AND **TWO (2)** QUESTIONS FROM **PART B.** 2. THIS FINAL EXAMINATION IS CONDUCTED VIA ☐ Open book ☒ Closed book 3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION

THIS QUESTION PAPER CONSISTS OF **FIFTEEN (15)** PAGES

PART A

Q1 Discuss, why is it important for the highway project to conduct road safety audits? Provide examples to support your points of view.

(10 marks)

Q2 Imagine you are part of a road safety planning team tasked with reducing pedestrian fatalities at a busy urban intersection. The intersection experiences a high volume of pedestrian due to nearby schools, markets, and residential areas. Your team aims to develop effective interventions to enhance pedestrian safety. Using the Haddon Matrix method, analyze the situation and propose a comprehensive road safety improvement plan for this intersection. Consider the following phases in time of the event:

(a) Pre-Crash Phase

(5 marks)

(b) Crash Phase

(5 marks)

(c) Post-Crash Phase

(5 marks)

PART B

Q3 Answer the following questions,

(a) Explain the fundamental relationship between speed, density, and flow in traffic flow theory. How do these variables interact, and what implications do they have for traffic management and roadway design?.

(10 marks)

(b) **Figure Q3.1** shows a section of freeway. It is a four-lane freeway with the following characteristics during peak hour:

- Two lanes per direction
- 3.3 m lane width
- 0.6 m lateral clearance
- Commuter traffic
- 5% trucks and buses
- 0.6 interchanges per kilometer
- Rolling terrain

This roadway has a current peak demand of 2,000 veh/h per direction. The peak hour-factor is 0.92, and there are no recreational vehicles in the traffic stream. At what level of service will the freeway operate during its peak period of demand?

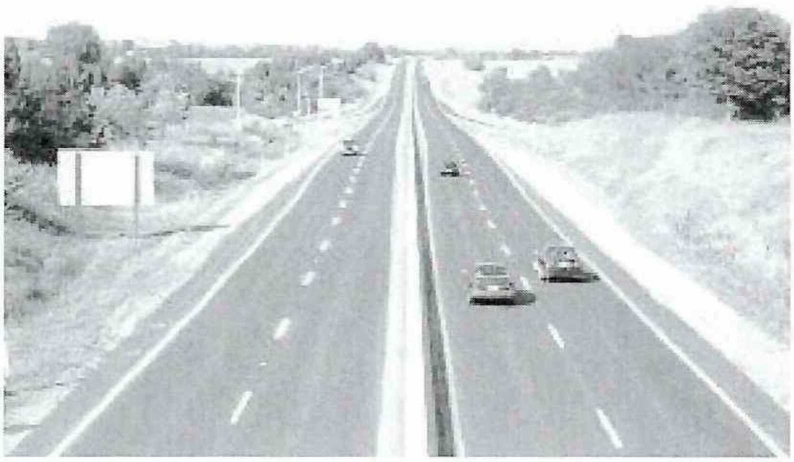


Figure Q3.1 Freeway segment

(15 marks)

Q4 Answer the following questions,

(a) **Table Q4.1** shows the parking data obtained using License Plate Survey Method at Jalan Cengal, Batu Pahat town. The data was collected for 2 hours with interval of 15 minutes.

Table Q4.1 Parking data at Jalan Cengal

Space num.	Time at the beginning of the patrol							
	09:15 AM	09:30 AM	09:45 AM	10:00 AM	10:15 AM	10:30 AM	10:45 AM	11:00 AM
1	2882	√	√	√		4551	√	√
2	7763			8363	√	√	9338	√
3	779	√	√	√		2559	1891	√
4	654	2128	√	√	√	√	√	√
5	8847	√	3315	√	√	√	√	√
6	4911	√	√	√	√	√	√	√
7	1418	√	√	7775	√	√	√	√

Note:

a. The numbers represent the first time that a vehicle parked in the space.
b. The check marks (√) indicate that the same vehicle was in the space on the next circulation.

(i) Determine the parking duration for these 7 parking spaces.

(2 marks)

(ii) Calculate the parking turnover for these 7 parking spaces over a 2-hour period.

(2 marks)

(iii) Find the parking occupancy for the facility during the first 1-hour period.

(2 marks)

(iv) Based on the results from **Q4 (a) (i), (ii)** and **(iii),** give your opinion if more parking spaces at Jalan Cengal are required? Justify your answer.

(4 marks)

(b) It has been found that the traffic peak hour factor in one city approached 0.98. Additionally, the open space parking that is available indicates that there is a 0.5 chance that someone will not find a place to park. Examine the current circumstances and make recommendations for how to employ the three kinds of traffic management techniques—"Improve Capacity," "Allocate Priorities," and "Restraint"—to reduce the traffic issue in these specific places. Provide an example in the form of a table that demonstrates at least **TWO (2)** objectives and **THREE (3)** techniques used for each of the 3 groups.

(15 marks)

Q5 **Table APPENDIX A.1** shows traffic flow data, lane width for each approach at a signalized intersection that has four phases. The intersection is on level ground, while the amber time, a = 3 sec, all red interval, R = 2 sec and driver reaction time, l = 2 sec (phase 1 and 3) and 3 sec (phase 2 and 4).

(a) Complete **Table APPENDIX A.1**. and attach it in your answer script.

(10 marks)

(b) Sketch a timing diagram.

(10 marks)

(c) Sketch a phase diagram.

(2 marks)

(d) Discuss the importance value all red time (R) for intersection design.

(3 marks)

- END OF QUESTIONS -

APPENDIX A

Name : ______________________________ Matric No :________________

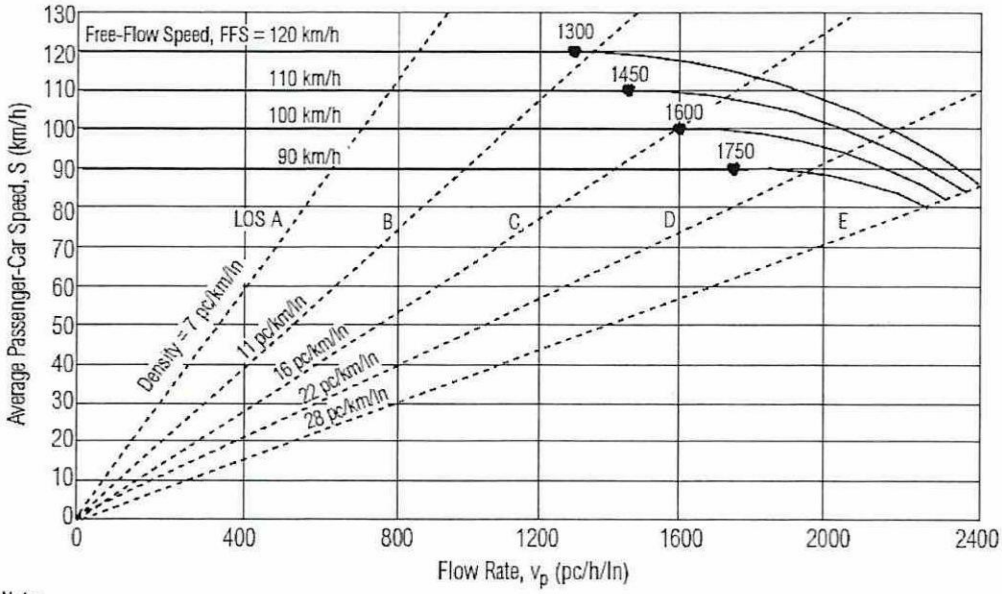
Table APPENDIX A.1: Traffic flow (pcu/hour), lane width (m) and turning radius (m) values for each phase and movement.

Phase	Phase 1			Phase 2			Phase 3			Phase 4		
Movement	WR	WT	WL	ER	ET	EL	NR	NT	NL	SR	ST	SL
Traffic Flow, q (pcu/hour)	85	150	90	50	200	55	40	100	50	55	200	60
Lane Width (m)	3.50			3.50			3.00			3.00		
Saturation Flow (pcu/hour)												
F_l												
F_R												
Adjusted Saturation Flow, S (pcu/hour)												
$y = q/S$												
$y_{critical}$												
Y												

Notes:

WR: West Right Turn	ER: East Right Turn	NR: North Right Turn	SR: South Right Turn
WT: West Through Traffic	ET: East Through Traffic	NT: North Through Traffic	ST: South Through Traffic
WL: West Left Turn	EL: East Left Turn	NL: North Left Turn	SL: South Left Turn

APPENDIX B

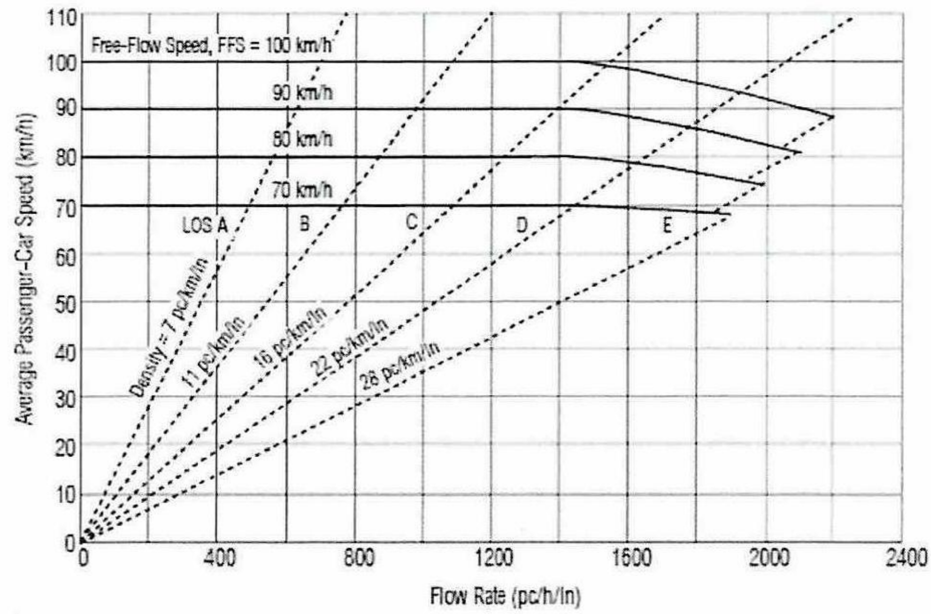


Note:
Capacity varies by free-flow speed. Capacity is 2400, 2350, 2300, and 2250 pc/h/ln at free-flow speeds of 120, 110, 100, and 90 km/h, respectively.

For $90 \le FFS \le 120$ and for flow rate (v_p)
$(3100 - 15FFS) < v_p \le (1800 + 5FFS)$,

$$S = FFS - \left[\frac{1}{28}(23FFS - 1800)\left(\frac{v_p + 15FFS - 3100}{20FFS - 1300}\right)^{2.6}\right]$$

For $90 \le FFS \le 120$ and
$v_p \le (3100 - 15FFS)$,
$S = FFS$



Note:
Maximum densities for LOS E occur at a v/c ratio of 1.0. They are 25, 26, 27, and 28 pc/km/ln at FFS of 100, 90, 80, and 70 km/h, respectively. Capacity varies by FFS. Capacity is 2,200, 2,100, 2,000, and 1,900 pc/h/ln at FFS of 100, 90, 80, and 70 km/h, respectively.

For flow rate (v_p), v_p > 1400 and
$90 < FFS \leq 100$ then

$$S = FFS - \left[\left(\frac{9.3}{25}FFS - \frac{630}{25}\right)\left(\frac{v_p - 1{,}400}{15.7FFS - 770}\right)^{1.31}\right]$$

For v_p > 1,400 and
$80 < FFS \leq 90$ then

$$S = FFS - \left[\left(\frac{10.4}{26}FFS - \frac{696}{26}\right)\left(\frac{v_p - 1{,}400}{15.6FFS - 704}\right)^{1.31}\right]$$

For v_p > 1,400 and
$70 < FFS \leq 80$ then

$$S = FFS - \left[\left(\frac{11.1}{27}FFS - \frac{728}{27}\right)\left(\frac{v_p - 1{,}400}{15.9FFS - 672}\right)^{1.31}\right]$$

For v_p > 1,400 and
FFS = 70 then

$$S = FFS - \left[\left(\frac{3}{28}FFS - \frac{75}{14}\right)\left(\frac{v_p - 1{,}400}{25FFS - 1{,}250}\right)^{1.31}\right]$$

For $v_p \leq 1{,}400$, then
S = FFS

Figure APPENDIX B.2: Speed-Flow Curves and Level of Service for Multilane Highways

Table APPENDIX B.1: Adjustment for lane width for basic freeway segments and multilane highways

Lane Width (m)	Reduction in FFS (km/h)
3.6	0.0
3.5	1.0
3.4	2.1
3.3	3.1
3.2	5.6
3.1	8.1
3.0	10.6

Table APPENDIX B.2: Passenger car equivalents for trucks and buses on basic freeway segments and multilane highways

Factor	Type of Terrain		
	Flat	Rolling	Mountainous
E_T (trucks and buses)	1.5	2.5	4.5
E_R (recreational vehicles)	1.2	2.0	4.0

Table APPENDIX B.3: Adjustment for left shoulder lateral clearance for basic freeway segments

Left shoulder lateral clearance (m)	Reduction in FFS (km/h)			
	Lanes in one direction			
	2	3	4	5
≥ 1.8	0.0	0.0	0.0	0.0
1.5	1.0	0.7	0.3	0.2
1.2	1.9	1.3	0.7	0.4
0.9	2.9	1.9	1.0	0.6
0.6	3.9	2.6	1.3	0.8
0.3	4.8	3.2	1.6	1.1
0.0	5.8	3.9	1.9	1.3

Table APPENDIX B.4: Adjustment for lateral clearance for multilane highways

Four-lane Highways		Six-Lane Highways	
Total Lateral Clearance (m)	**Reduction in FFS (km/h)**	**Total Lateral Clearance (m)**	**Reduction in FFS (km/h)**
3.6	0.0	3.6	0.0
3.0	0.6	3.0	0.6
2.4	1.5	2.4	1.5
1.8	2.1	1.8	2.1
1.2	3.0	1.2	2.7
0.6	5.8	0.6	4.5

Note: Total lateral clearance is the sum of the lateral clearances of the median (if greater than 1.8 m, use 1.8 m) and shoulder (if greater than 1.8 m, use 1.8 m). Therefore, for purposes of analysis, total lateral clearance cannot exceed 3.6 m.

Table APPENDIX B.5: Adjustment for number of lanes for basic freeway segments

Number of lanes in one direction	Reduction in FFS (km/h)
≥ 5	0.0
4	2.4
3	4.8
2	7.3

Note: For all rural freeway segments, f_N is 0.0

Table APPENDIX B.6: Adjustment for interchange density for basic freeway segments

Number of interchanges per km	Reduction in FFS (km/h)
≤ 0.3	0.0
0.4	1.1
0.5	2.1
0.6	3.9
0.7	5.0
0.8	6.0
0.9	8.1
1.0	9.2
1.1	10.2
1.2	12.1

Table APPENDIX B.7: Adjustment for median type for multilane highways

Median type	Reduction in FFS (km/h)
Divided	0.0
Undivided	2.6

Table APPENDIX B.8: Adjustment for access point density for multilane highways

Access points per km	Reduction in FFS (km/h)
0	0.0
6	4.0
12	8.0
18	12.0
≥ 24	16.0

Table APPENDIX B.9: Passenger car equivalents for trucks and buses on upgrades

Upgrade (%)	Length (km)	Percentage of Trucks and Buses								
		2	4	5	6	8	10	15	20	25
< 2	All	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
≥ 2 – 3	0.0 – 0.4	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	> 0.4 – 0.8	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	> 0.8 – 1.2	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	> 1.2 – 1.6	2.0	2.0	2.0	2.0	1.5	1.5	1.5	1.5	1.5
	> 1.6 – 2.4	2.5	2.5	2.5	2.5	2.0	2.0	2.0	2.0	2.0
	> 0.4 – 0.8	3.0	3.0	2.5	2.5	2.0	2.0	2.0	2.0	2.0

Table APPENDIX B.10: Level of service criteria for basic freeway segments and multilane highways

Level of service	Density (pc/km/lane)
A	0 ≤ D ≤ 7
B	7 < D ≤ 11
C	11 < D ≤ 16
D	16 < D ≤ 22
E	22 < D ≤ 28
F	> 28

Table APPENDIX B.11 : Relationship between effective lane width (W) and saturation flow (S)

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

Table APPENDIX B.12: Correction factor for the effect of gradient, F_g

Correction Factor, F_g	**Description**
0.85	For upward slope of 5%
0.88	For upward slope of 4%
0.91	For upward slope of 3%
0.94	For upward slope of 2%
0.97	For upward slope of 1%
1.00	For level grade
1.03	For downward slope of 1%
1.06	For downward slope of 2%
1.09	For downward slope of 3%
1.12	For downward slope of 4%
1.15	For downward slope of 5%

Table APPENDIX B.13 : Correction factor for the effect of turning radius, F_t

Correction Factor, F_t	**Description**
0.85	$R \leq 10$
0.90	$10m \leq R < 15m$
0.96	$15m \leq R < 30m$

Table APPENDIX B.14: Correction factors for turning traffic

% Turning Traffic	**Factor for right-turn, F_r**	**Factor for left-turn, F_l**
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	0.73	0.91
55	0.71	0.90
60	0.69	0.89

APPENDIX C

The following information may be useful. The symbols have their usual meaning.

$$v = \frac{n(L+C)}{\sum t_o} \qquad LO = \frac{\sum t_o \times 1000}{L+C} \qquad t_o = \frac{L+C}{v_s} \qquad R = \frac{\sum L_i}{D}$$

$$FFS = BFFS - f_{LW} - f_{LC} - f_N - f_{ID} \qquad FFS = BFFS - f_{LW} - f_{LC} - f_M - f_A$$

$$v_P = \frac{V}{PHF \times N \times f_{HV} \times f_P} \qquad f_{HV} = \frac{1}{1 + P_T(E_T - 1)} \qquad D = \frac{v_P}{S}$$

$$v = v_f - \frac{v_f}{k_j}k \qquad v_s = \frac{nL}{\sum t_i} \qquad v_t = \frac{\sum v_i}{n} \qquad v_t = v_s + \frac{\sigma^2}{v_s}$$

$$g = h - \frac{L}{v} \qquad c = g \times v \qquad k = \frac{1000}{s} \qquad h = \frac{s}{v} \qquad q = \frac{3600}{h}$$

$$q_m = \frac{v_f \times k_j}{4} \qquad I = R + a \qquad L = \sum (I - a) + \sum l \qquad g_n = \frac{y_n}{Y}(C - L)$$

$$G_n = g_n + l + R \qquad k_n = G_n - a - R \qquad S_{adj} = S \times f_g \times f_t \times f_l \times f_r$$

$$G_{ped} = 5 + \frac{W}{1.22} - I \qquad q = v \times k \qquad y = \frac{q}{S_{adj}} \qquad PHF = \frac{V}{4 \times V_{15}}$$

$$FV = PV(1+r)^n \qquad C_o = \frac{1.5L+5}{1-y} \qquad S = 525\,W \qquad x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$Parking\ duration = \frac{Number\ of\ observations}{Number\ of\ vehicles} \times Interval$$

$$Parking\ turnover = \frac{Number\ of\ parked\ vehicles}{Number\ of\ parking\ spaces}$$

$$Parking\ occupancy = \frac{Number\ of\ spaces\ occupied}{Number\ of\ parking\ spaces} \times 100\%$$

$$Probability\ of\ Rejection = \frac{\frac{A^M}{M!}}{1 + A + \frac{A^2}{2!} + \frac{A^3}{3!} + \frac{A^4}{4!} + \cdots + \frac{A^M}{M!}}$$

$$Space\ hour\ demand, D = \sum_{i=1}^{N} (n_i t_i),$$

$$\bar{x} = \frac{\sum fx}{n} \qquad Median = L + \left[\frac{\left(\frac{n}{2}\right) - f_L}{f_m}\right] \times C$$

$$s = \sqrt{\frac{\sum fx^2}{n-1} - \frac{(\sum fx)^2}{n(n-1)}}$$

$$S = 525\,W \qquad x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$