UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2023/2024

COURSE NAME	:	TRAFFIC ENGINEERING SAFETY
COURSE CODE	:	BFC 32302
PROGRAMME CODE	:	BFF
EXAMINATION DATE	:	JANUARY / FEBRUARY 2024
DURATION	:	2 HOURS 30 MINUTES
INSTRUCTIONS	:	1. ANSWER **ONE (1)** QUESTION 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 CONDUCTED VIA CLOSED BOOK

THIS QUESTION PAPER CONSISTS OF **SIXTEEN (16)** PAGES

PART A

Q1 Answer the following questions.

(a) As a professional traffic engineer, you have been tasked with the responsibility of assembling a team to conduct a Road Safety Audit (RSA) at a designated location.

(i) List **FOUR (4)** expertise, skills, and experience that your team of auditors should possess.

(4 marks)

(ii) Given that the aerial photography depicts the location as shown **in Figure Q1.1**. Discuss **SIX (6)** potential hazards that exists in that location.

(6 marks)

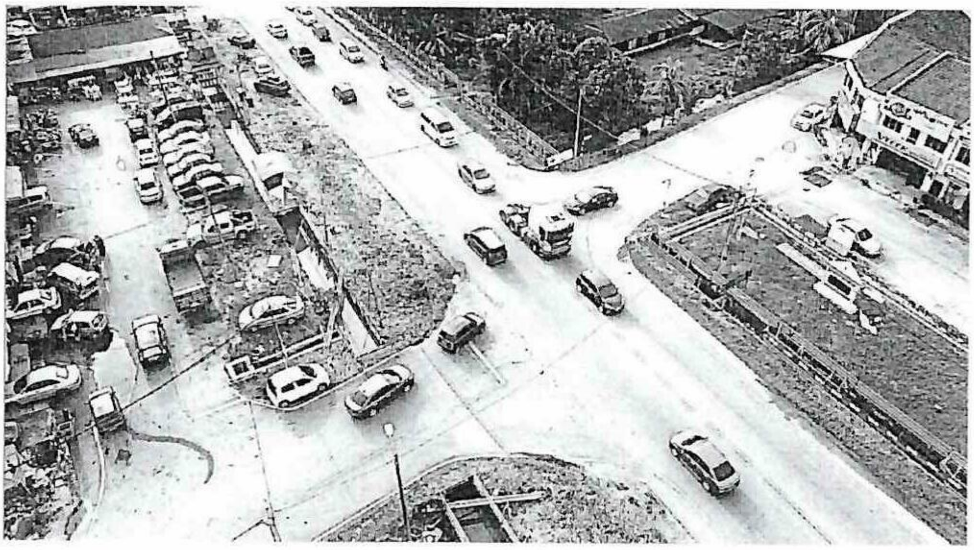


Figure Q1.1: Aerial Photography of designated location for RSA

(b) Environmental elements are significant determinant of traffic collisions. Provide **THREE (3)** environmental elements and describe **ONE (1)** appropriate technique to address each one of them.

(6 marks)

(c) Motorcycle accidents are becoming more common each year. As a traffic engineer at the Malaysian Institute of Road Safety Research (MIROS), you have been tasked with developing a strategy to enhance motorcycle safety in Malaysia for submission to the Ministry of Transport Malaysia. Briefly describe the strategies at least **THREE (3)** aspects for each category that considered Education, Enforcement and engineering (3E) concepts in your road accident plan.

(9 marks)

PART B

Q2 Answer the following questions.

(a) The free flow speed of the road segment is observed to be 60 km/h near zero density, and the corresponding jam density is 140 veh/km, presuming a linear speed-density relationship. Assume that a vehicle is 7 metres long on average.

(i) Write down the speed-density relationship and flow density equations.

(4 marks)

(ii) Draw the *v-k*, *v-q* and *q-k* diagrams indicating critical values, where v = speed, k = density and q = flow.

(8 marks)

(iii) Compute the speed and density corresponding to a flow of 1000 veh/hr

(5 marks)

(b) A rural motorway is designed with four lanes. Using the information below:

Two lanes per direction

3.3 m lane width

0.6 m lateral clearance

Commuter traffic

2,000 veh/h peak hour volume per direction

5% trucks and buses

0.92 peak hour factor (PHF)

0.6 interchanges per kilometer

Rolling terrain

(i) Determine the level of service (LOS) of an existing rural four-lane freeway.

(6 marks)

(ii) Find the additional traffic to reach capacity.

(2 marks)

Q3 Traffic management is the process of modifying or adapting the use of existing road systems in order to enhance traffic operations without the need for significant new construction.

(a) Provide **ONE (1)** traffic management technique for the issues given below:

(i) Congestion of traffic in the central business district (CBD)

(ii) Sharing a pathway with motor vehicles compromises the safety of cyclists and pedestrians.

(iii) Constantly, the bus service is delayed due to traffic congestion.

(3 marks)

(b) A parking survey has been conducted in one parking lot. The survey's findings are shown in **Table Q3.1.**

Table Q3.1 : Parking survey findings

Space No.	2.00 pm	2.30 pm	3.00 pm	3.30 pm	4.00 pm
100	021	✓	✓		
101					032
102			432	✓	
103		T311	✓	✓	
104	322				
105		132			

(i) Specify **TWO (2)** primary objectives for conducting parking survey.

(2 marks)

(ii) Analyse the parking duration for space 103.

(2 marks)

(iii) Determine the parking turnover for parking spaces 102 to 105 for the duration of the study.

(2 marks)

(iv) Calculate the parking occupancy of parking spaces 100 to 102 for the first hour.

(2 marks)

(c) The owner of a parking garage in a Central Business District has observed that 20% of those seeking parking are turned away daily between peak hours of 12 p.m. to 2.00 p.m. due to a scarcity of available parking spaces. An analysis of parking garage data reveals that 60% of parkers are commuters, with an average parking duration of 9 hours, and the remaining 40% are consumers, with an average parking duration of 2 hours. Given that the garage could accommodate 200 vehicles park at one time.

(i) Analyse and calculate the sum of space-hour served.

(6 marks)

(ii) Calculate the parking demand not served.

(2 marks)

(iii) Determine the space-hour demanded.

(2 marks)

(iv) Provide the number of additional spaces that could accommodate the turned-away vehicles.

(2 marks)

(v) If the owner of this garage has considered the inclusion of this additional parking area, provide your perspective along with reasoning as to whether it would be worthwhile to do so.

(2 marks)

Q4 **Table APPENDIX A.1** shows traffic flow data, lane width and turning radius for each approach at a signalized intersection that has two 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.

(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) Give your comment if the intersection is on a gradient, has no All Red Time (R), and every movement increase at an annual rate of 5% in next 5 years.

(3 marks)

- END OF QUESTIONS -

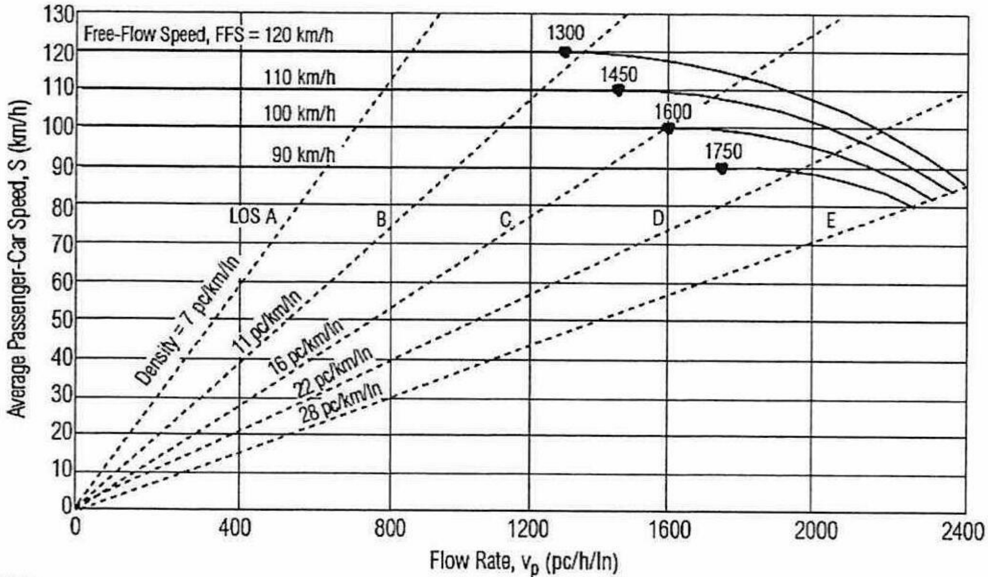
APPENDIX A

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	
Movement	West Right	West Through	East Left	East Through	South Right	South Left
Traffic Flow, q (pcu/hour)	285	400	150	450	350	450
Lane Width (m)	3.50	5.50	3.50	5.50	3.75	3.75
Turning Radius (m)	12					
Saturation Flow (pcu/hour)						
F_t						
F_l						
F_R						
Adjusted Saturation Flow, S (pcu/hour)						
y = q/S						
$y_{critical}$						
Y						

APPENDIX B



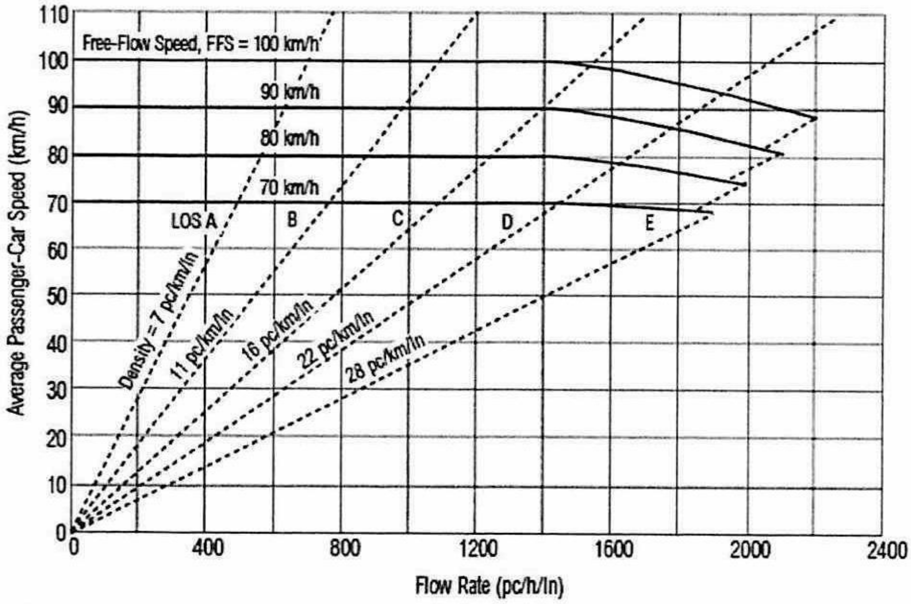
Note:
Capacity varies by free-flow speed. Capacity is 2400, 2350, 2300, and 2250 pc/h/ln at free-flow speeds of 120, 110, 100, and 90 km/h, respectively.

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
$v_p \le (3100 - 15FFS)$,
$S = FFS$

Figure APPENDIX B.1: Speed-Flow Curves and Level Of Service For Basic Freeway Segments



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
$90 < FFS \le 100$ 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
$80 < FFS \le 90$ 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
$70 < FFS \le 80$ 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 $v_p \le 1{,}400$, then
S = FFS

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

Table APPENDIX B.3: 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.4: 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.5: 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.6: 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.7: 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.8: 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.9: Adjustment for median type for multilane highways

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

Table APPENDIX B.10: 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.11: 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
$\geq 2 - 3$	$0.0 - 0.4$	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.12: Level of service criteria for basic freeway segments and multilane highways

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

Table APPENDIX B.13 : 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.14: 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.15 : 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.16 : 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.

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

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

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

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

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

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

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

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

$$FV = PV(1+r)^n$$

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

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

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

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

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

$$\bar{x} = \frac{\sum fx}{n}$$

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

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

$$S = 525\ W$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$