UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2021/2022

COURSE NAME	:	TRAFFIC ENGINEERING AND SAFETY
COURSE CODE	:	BFC 32302
PROGRAMME CODE	:	BFF
EXAMINATION DATE	:	JANUARY / FEBRUARY 2022
DURATION	:	2 HOURS 30 MINUTES
INSTRUCTIONS	:	1. ANSWER **ONE (1)** QUESTION FROM **SECTION A** AND **TWO (2)** QUESTIONS FROM **SECTION B.** 2. THIS FINAL EXAMINATION IS AN **ONLINE** ASSESSMENT AND CONDUCTED VIA **CLOSE BOOK.**

THIS QUESTION PAPER CONSISTS OF **THIRTEEN (13)** PAGES

SECTION A

Q1 (a) Discuss your opinion about the potential hazards and possible causes from the group riding activity as shown in **Figure Q1(a)**.

(15 marks)

(b) Write your prediction on what will happen to road traffic and safety if the COVID-19 pandemic continues until 2023 in Malaysia.

(5 marks)

(c) The Malaysian government has implemented many road safety campaigns every year, but the accident rate is still high. These campaigns have been less successful in creating awareness among road users. Give your suggestions on how to improve the quality of these campaigns.

(5 marks)

SECTION B

Q2 (a) A traffic pacing operation was conducted by a highway patrol unit (see **Figure Q2(a)**) to slow down upstream traffic on a highway due to maintenance works being conducted downstream. The speed of the highway patrol unit during this operation was 40 km/h and the upstream traffic density was 150 vehicles/km. After passing the location of the maintenance works, the highway patrol unit left the traffic stream, causing traffic speed to increase to 70 km/h and density to settle at 50 vehicles/km.

(i) Develop a mathematical relationship between speed and density.

(5 marks)

(ii) Will the upstream traffic flow reach the maximum flow?

(5 marks)

(b) A 2-km southbound segment of an urban freeway is located on flat terrain. This segment has three 3.5 m lanes and 1.2 m left shoulder clearance. There is one interchange along this segment and motorists using this freeway are regular drivers. Based on the traffic data given below, evaluate the performance of this freeway segment.

Peak hourly volume:	3,000 vehicles per hour
Composition of trucks and buses:	12%
Peak hour factor:	0.95

(15 marks)

Q3 (a) The public transportation sector is facing huge losses and fiscal revenue has been affected since the implementation of Movement Control Order (MCO) due to the COVID-19 pandemic. Hence, to ensure the survival of transport operators, the government needs to implement initiatives and strategies. Suggest **THREE (3)** initiatives or strategies that may be beneficial to the public and transport operators. Explain the merits and demerits for each of them.

(9 marks)

(b) The Batu Pahat Municipal Council plans to provide an alternative large open space parking lot that will be able to accommodate up to 500 vehicles to meet high parking demand. However, this open space parking is to be operated at a low-cost budget and minimal manpower as an option to easily maintain its operation. Propose and sketch a practical idea to solve the problem without investing too much capital into this project.

(8 marks)

(c) During a parking study, it was observed for 3 to 6 hours that around 75 to 95 vehicles enter the parking lot of a local grocery store. The parking lot has only 10 parking spaces including one space reserved for disabled drivers (OKU). Customers park their cars for an average time of between 15 to 30 minutes. Determine the probability that incoming vehicles do not find a parking space.

(8 marks)

Q4 (a) It is essential to understand several key concepts and definitions used for designing a signal phasing for an intersection. In your own words, describe the following parameters and explain the effect on these parameters if a signalised intersection changes from 3-phase to 4-phase?

(i) Saturation flow rate

(ii) Lost time

(iii) Cycle time

(9 marks)

(b) An intersection has a 4-phase signal with the movements allowed in each phase and corresponding demand and saturation flow rates shown in **Table Q4(b)**. Calculate the sum of the flow ratios for the critical lane groups. From the given saturation flow, sketch the intersection with proper lane width.

(10 marks)

(c) The critical lane group flow rates for the first three phases of a pre-timed 4-phase signal system are 230 pcu/h, 178 pcu/h and 205 pcu/h respectively. The saturation flow rates are 1885 pcu/h/ln for all phases, and the lost time is known to be 3 seconds for each phase. If the cycle length is 60 seconds, estimate the effective green time of the fourth phase.

(6 marks)

- END OF QUESTIONS -

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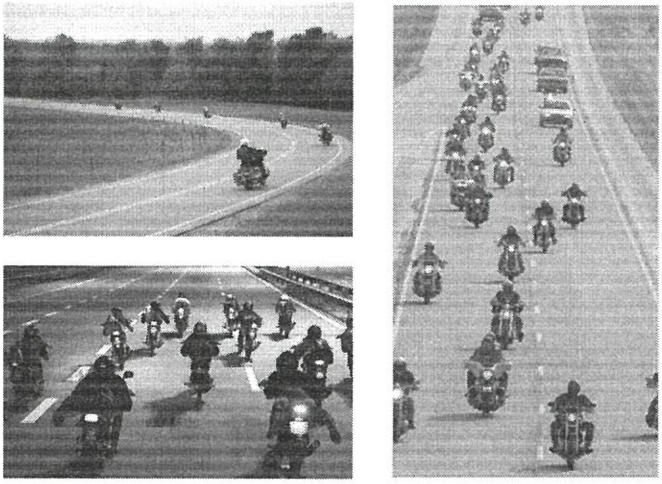

Figure Q1(a): Group motorcycle riding

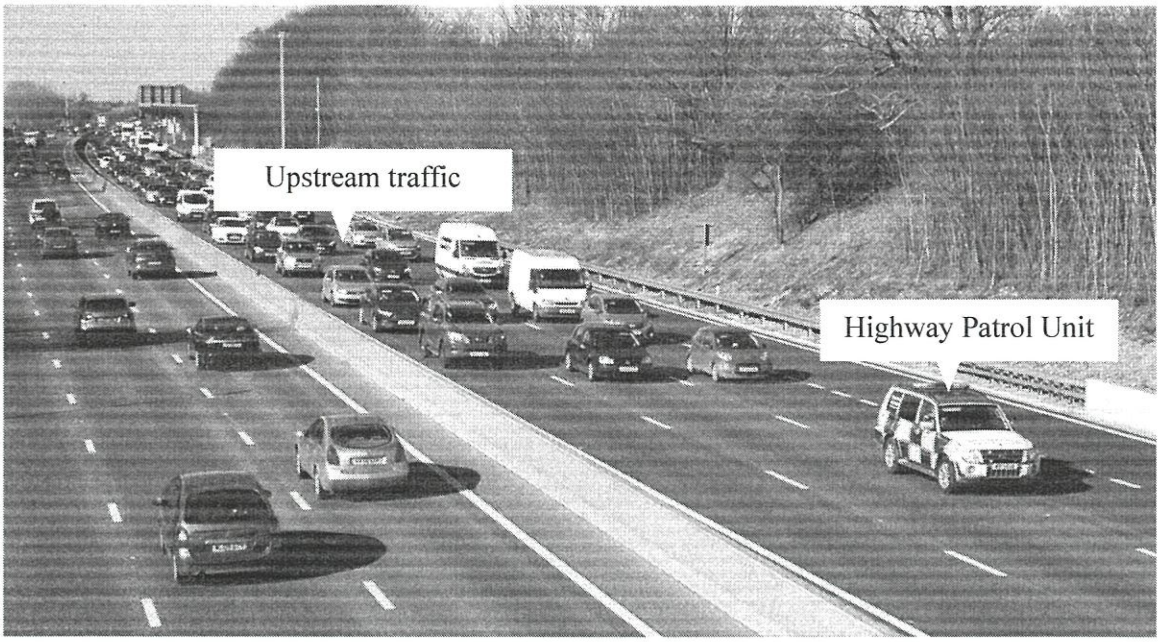

Figure Q2(a): Traffic pacing operation on a highway

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Table Q4(b): Flow rates (in pcu/h) for four phases of a traffic signal system at an intersection

Phase	1		2		3		4	
Allowed Movements	$N_{S\&L/T}$	$S_{S\&L/T}$	$N_{R/T}$	$S_{R/T}$	$E_{S\&L/T}$	$W_{S\&L/T}$	$E_{R/T}$	$W_{R/T}$
Demand flow	300	200	350	375	400	350	470	400
Saturation flow	1965	1965	1885	1885	1915	1915	1885	1885

N: North approach; E: East approach; W: West approach; S: South approach; R/T: Right-turn; S&L/T: Straight and Left-turn

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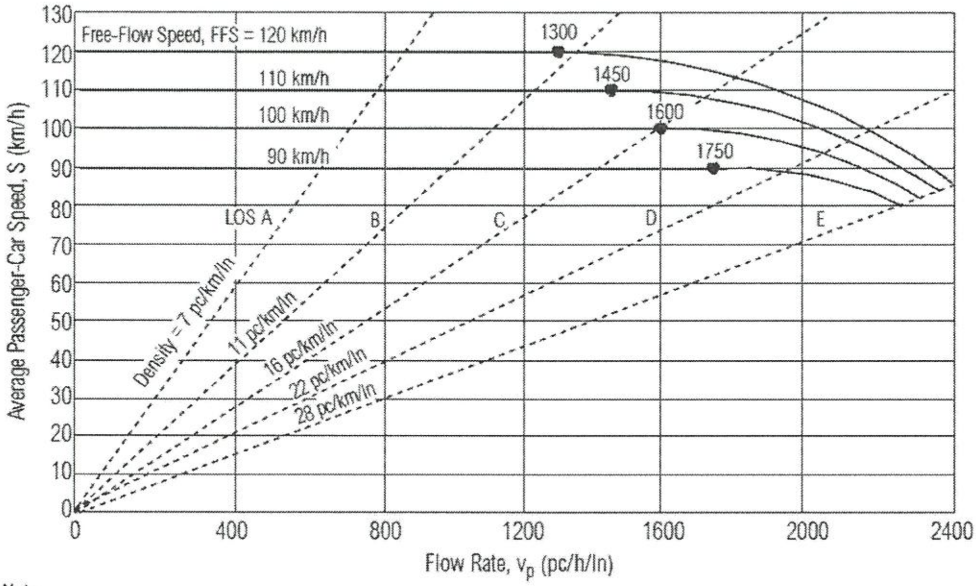
APPENDIX A: DESIGN CHARTS AND TABLES

I. Speed-Flow Curves and Level of Service for Basic Freeway Segments



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

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

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

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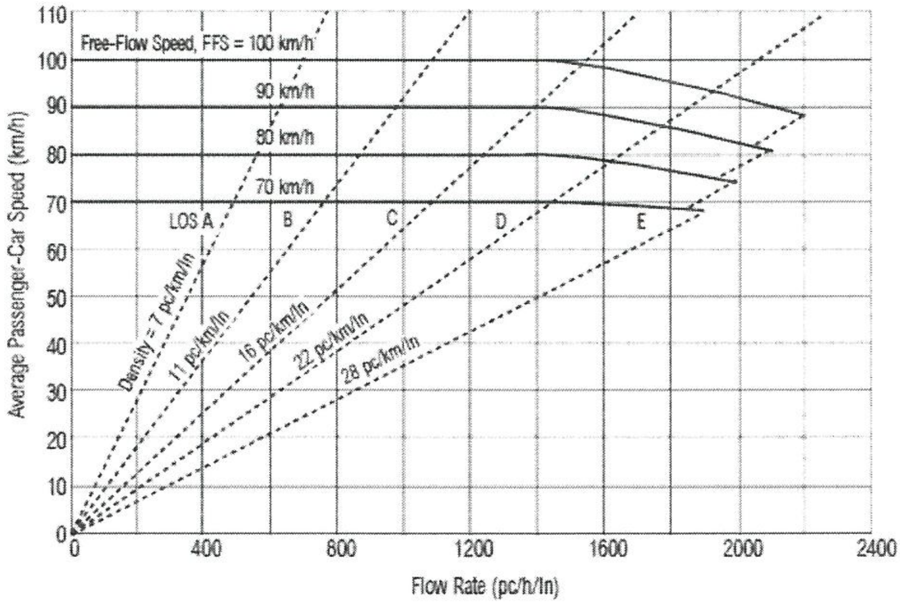
II. Speed-Flow Curves and Level of Service for Multilane Highways



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 $S = FFS$

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III. 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

IV. 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

V. 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

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VI. 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.

VII. 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

VIII. 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

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IX. Adjustment for median type for multilane highways

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

X. 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

XI. 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

XII. 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

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XIII. Correction factor for the effect of gradient, F_g

Correction Factor, F_g	Description
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%

XIV. Correction factor for the effect of turning radius, F_t

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

XV. 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

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APPENDIX B: FORMULAS

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

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

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

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

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

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

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

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

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

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

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

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

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

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