UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2015/2016

COURSE NAME	:	ADVANCED TRAFFIC ENGINEERING
COURSE CODE	:	BFT 40503
PROGRAMME CODE	:	BFF
DATE	:	JUNE/JULY 2016
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **NINE (9)** PAGES

Q1 (a) Discuss the relationship between Speed-Density and Flow-Density with an assistance of relevant diagram.

(5 marks)

(b) A gap study was conducted at the merging area of an on-ramp with a section of an expressway. **Table 1** shows the data that was collected. The peak hour volume on the expressway was found to be 1,810 vehicles per hour.

(i) Determine the critical gap.

(15 marks)

(ii) Estimate the number of acceptable gaps for the on-ramp vehicles that will occur during the peak hour. (Assume that the distribution of traffic is Poison).

(5 marks)

Q2 (a) (i) State **FOUR (4)** factors that should be considered when providing walking and crossing facilities for pedestrians.

(4 marks)

(ii) Explain **THREE (3)** measures that can enhance the ability of pedestrians to cross the road safely.

(6 marks)

(b) The number of private automobiles in your city has been steadily increasing every year, causing major concern about congestion and accidents in the city. You, as a traffic engineering consultant, was contacted by your city council and asked to prepare a proposal to the city council board of directors on how to improve pedestrian safety. Prepare a draft that explains **THREE (3)** types of pedestrian crossing with its warrant for installation that can be provided in the city.

(15 marks)

Q3 A two-lane arterial (class II) section passes through two pre-timed signalised intersections at spacings of 600 m and 800 m respectively. The green times are 40 sec and 30 sec respectively. The street experiences high right-turn volume, served by a permitted phase and an exclusive turn lane. Determine the level of service for each segment, given the following information:

Field measured free flow speed (*FFS*)	= 65 km/h
Cycle length (*C*)	= 80 sec
Lane group capacity (*c*)	= 1,500 veh/h
Arrival type	= 3
Analysis period (*T*)	= 0.25 hours
Initial queue at Intersection 1 (Q_b)	= 20 vehicles
Volume-to-capacity ratio (*X*)	= 0.85
Upstream filtering/metering adjustment factor (*I*)	= 0.407

Use the worksheet provided in **Table 2** and show your working for Segment 1.

(25 marks)

Q4 (a) Define the term Geographic Information System (GIS).

(5 marks)

(b) GIS has a great potential in transportation system management. Propose and discuss how GIS can be used to improve the quality and security of public transport service in Malaysia. Identify and explain any **THREE (3)** related examples to support your answer.

(15 marks)

(i) Explain another **TWO (2)** potential applications of GIS in transportation.

(5 marks)

- END OF QUESTIONS -

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Table 1: Data for accepted and rejected gaps

Gap, t (sec)	Number of accepted gap less than t	Number of rejected gap more than t
0	0	128
1	3	110
2	5	88
3	16	66
4	23	54
5	39	27
6	64	15
7	98	4
8	130	0

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Name: .... Matric Card No.: ....

Note: Use this worksheet to answer Q2 and attach it with your answer script

Table 2: Arterial LOS Worksheet

Input Parameters		
Descriptor	Segments	
	1	2
Cycle length, C (s)	80	80
Green time, g (s)	40	30
Green-to-cycle length ratio, g/C		
Volume-to-capacity ratio for lane group, X	0.85	0.85
Capacity of lane group, c (veh/h)	1,500	1,500
Arrival type, AT	3	3
Length of segment, L (km)	0.4	0.6
Initial queue, Q_b (veh)	20	-
Arterial class	II	II
Free flow speed, FFS (km/h)	65	65
Running time, T_R (s)		
Delay Computation		
Uniform delay, d_1 (s)		
Signal control adjustment factor, k		
Upstream filtering / metering adjustment factor, I		
Incremental delay, d_2 (s)		
Initial queue delay, d_3 (s)		
Progression adjustment factor, PF		
Control delay, $d = d_1 * PF + d_2 + d_3$		
Segment LOS Determination		
Segment travel time, ST (s) $ST = T_R + d$		
Segment travel speed, S_A (km/h)		
Segment LOS		

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Table 3: Urban street LOS by class (HCM, 2000)

Urban Street Class	I	II	III	IV
Range of free-flow speeds (FFS)	90 to 70 km/h	70 to 55 km/h	55 to 50 km/h	55 to 40 km/h
Typical FFS	80 km/h	65 km/h	55 km/h	45 km/h
LOS	Average Travel Speed (km/h)			
A	> 72	> 59	> 50	> 41
B	> 56–72	> 46–59	> 39–50	> 32–41
C	> 40–56	> 33–46	> 28–39	> 23–32
D	> 32–40	> 26–33	> 22–28	> 18–23
E	> 26–32	> 21–26	> 17–22	> 14–18
F	≤ 26	≤ 21	≤ 17	≤ 14

Table 4: Relationship between arrival type and platoon ratio (HCM, 2000)

Arrival Type	Range of Platoon Ratio (R_p)	Default Value (R_p)	Progression Quality
1	≤ 0.50	0.333	Very poor
2	> 0.50–0.85	0.667	Unfavorable
3	> 0.85–1.15	1.000	Random arrivals
4	> 1.15–1.50	1.333	Favorable
5	> 1.50–2.00	1.667	Highly favorable
6	> 2.00	2.000	Exceptional

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Table 5: Segment running time per kilometer (HCM, 2000)

Urban Street Class	I			II			III		IV		
FFS (km/h)	90[a]	80[a]	70[a]	70[a]	65[a]	55[a]	55[a]	50[a]	55[a]	50[a]	40[a]
Average Segment Length (m)	Running Time per Kilometer (s/km)										
100	b	b	b	b	b	b	-	-	-	129	159
200	b	b	b	b	b	b	88	91	97	99	125
400	59	63	67	66	68	75	75	78	77	81	96
600	52	55	61	60	61	67	d	d	d	d	d
800	45	49	57	56	58	65	d	d	d	d	d
1000	44	48	56	55	57	65	d	d	d	d	d
1200	43	47	54	54	57	65	d	d	d	d	d
1400	41	46	53	53	56	65	d	d	d	d	d
1600	40[c]	45[c]	51[c]	51[c]	55[c]	65[c]	d	d	d	d	d

Notes:

a. It is best to have an estimate of FFS. If there is none, use the table above, assuming the following default values:

For Class	FFS (km/h)
I	80
II	65
III	55
IV	45

b. If a Class I or II urban street has a segment length less than 400 m, (a) reevaluate the class and (b) if it remains a distinct segment, use the values for 400 m.

c. For long segment lengths on Class I or II urban streets (1600 m or longer), FFS may be used to compute running time per kilometer. These times are shown in the entries for a 1600-m segment.

d. Likewise, Class III or IV urban streets with segment lengths greater than 400 m should first be reevaluated (i.e., the classification should be confirmed). If necessary, the values above 400 m can be extrapolated.

Although this table does not show it, segment running time depends on traffic flow rates; however, the dependence of intersection delay on traffic flow rate is greater and dominates in the computation of travel speed.

Table 6: Recommended upstream filtering / metering adjustment factor for lane groups with upstream signals (HCM, 2000)

	Degree of Saturation at Upstream Intersection, X_u						
	0.40	0.50	0.60	0.70	0.80	0.90	≥ 1.0
I	0.922	0.858	0.769	0.650	0.500	0.314	0.090

Note: $I = 1.0 - 0.91 X_u^{2.68}$ and $X_u \leq 1.0$.

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Table 7: Progression adjustment factors for uniform delay calculation (HCM, 2000)

Green Ratio (g/C)	Arrival Type (AT)					
	AT 1	AT 2	AT 3	AT 4	AT 5	AT 6
0.20	1.167	1.007	1.000	1.000	0.833	0.750
0.30	1.286	1.063	1.000	0.986	0.714	0.571
0.40	1.445	1.136	1.000	0.895	0.555	0.333
0.50	1.667	1.240	1.000	0.767	0.333	0.000
0.60	2.001	1.395	1.000	0.576	0.000	0.000
0.70	2.556	1.653	1.000	0.256	0.000	0.000
f_{PA}	1.00	0.93	1.00	1.15	1.00	1.00
Default, R_p	0.333	0.667	1.000	1.333	1.667	2.000

Notes:
$PF = (1 - P)f_{PA}/(1 - g/C)$.
Tabulation is based on default values of f_p and R_p.
$P = R_p \cdot g/C$ (may not exceed 1.0).
PF may not exceed 1.0 for AT 3 through AT 6.

Table 8: Signal control adjustment factor for controller type (HCM, 2000)

Unit Extension (s)	Degree of Saturation (X)					
	≤ 0.50	0.60	0.70	0.80	0.90	≥ 1.0
≤ 2.0	0.04	0.13	0.22	0.32	0.41	0.50
2.5	0.08	0.16	0.25	0.33	0.42	0.50
3.0	0.11	0.19	0.27	0.34	0.42	0.50
3.5	0.13	0.20	0.28	0.35	0.43	0.50
4.0	0.15	0.22	0.29	0.36	0.43	0.50
4.5	0.19	0.25	0.31	0.38	0.44	0.50
5.0[a]	0.23	0.28	0.34	0.39	0.45	0.50
Pretimed or Nonactuated Movement	0.50	0.50	0.50	0.50	0.50	0.50

Notes:
For a unit extension and its k_{min} value at $X = 0.5$: $k = (1 - 2k_{min})(X - 0.5) + k_{min}$, where $k \geq k_{min}$, and $k \leq 0.5$.
a. For a unit extension more than > 5.0, extrapolate to find k, keeping $k \leq 0.5$.

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The following equations may be useful to you:

$$v = v_f - \frac{v_f}{k_j}k \qquad v = v_f e^{\left(\frac{-k}{k_j}\right)} \qquad v = C\ln\left(\frac{k_j}{k}\right) \qquad Y = a - bX \qquad a = \frac{\sum Y}{n} - b\frac{\sum X}{n}$$

$$b = \frac{n\left(\sum XY\right) - \left(\sum X\right)\left(\sum Y\right)}{n\left(\sum X^2\right) - \left(\sum X\right)^2} \qquad r = \frac{n\left(\sum XY\right) - \left(\sum X\right)\left(\sum Y\right)}{\sqrt{\left(n\left(\sum X^2\right) - \left(\sum X\right)^2\right)\left(n\left(\sum Y^2\right) - \left(\sum Y\right)^2\right)}}$$

$$S_A = \frac{3600L}{T_R + d} \qquad d = d_1 * PF + d_2 + d_3 \qquad d_1 = \frac{0.5C\left(1 - \frac{g}{C}\right)^2}{1 - \left(\frac{g}{C}\right)min\left(X, 1.0\right)}$$

$$d_2 = 900T\left[\left(X-1\right) + \sqrt{\left(X-1\right)^2 + \frac{8kIX}{cT}}\right] \qquad I = 1.0 - 0.91X_u^{\ 2.68} \qquad d_3 = \frac{1800Q_b(1+u)t}{cT}$$

$$t = 0 \ if \ Q_b = 0, \quad else \quad t = min\left(T, \frac{Q_b}{c\left[1 - min\left(1, X\right)\right]}\right)$$

$$u = 0 \ if \ t < T, \quad else \quad u = 1 - \frac{cT}{Q_b\left[1 - min\left(1, X\right)\right]} \qquad v_w = \frac{q_2 - q_1}{k_2 - k_1} \qquad X = \frac{v}{c}$$

$$c = s \times N \times \left(\frac{g}{C}\right) \qquad \tau_{\min} = \delta + \frac{W + L}{v_o} + \frac{v_o}{2a} \qquad C_o = \frac{1.5L + 5}{1 - Y}$$

$$L = \sum l + R \qquad G_e = \frac{y}{Y}(C - L) \qquad G_a = G_e + l - \tau$$

$$If \ W_E > 3, \quad G_p = 3.2 + \frac{L}{S_p} + \left(2.7\frac{N_{ped}}{W_E}\right) \qquad If \ W_E \le 3, \quad G_p = 3.2 + \frac{L}{S_p} + \left(0.27N_{ped}\right)$$

$$X_c = \sum\left(\frac{v}{s}\right)_c * \frac{C}{C - L} \qquad t_c = t_1 + \frac{(t_2 - t_1)(p - q)}{(r - s) + (p - q)} \qquad \lambda = \frac{V}{T} \qquad \mu = \lambda t$$

$$P(h \ge t) = e^{-\lambda t} \qquad P(h < t) = 1 - e^{-\lambda t}$$

$$Freq.(h \ge t) = (V - 1)e^{-\lambda t} \qquad Freq.(h < t) = (V - 1)(1 - e^{-\lambda t})$$