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Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION (ONLINE) SEMESTER II SESSION 2019/2020

COURSE NAME	:	ADVANCED TRAFFIC ENGINEERING
COURSE CODE	:	BFT40503
PROGRAMME CODE	:	BFF
EXAMINATION DATE	:	JULY 2020
DURATION	:	6 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

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THIS QUESTION PAPER CONSISTS OF **TWELVE (12)** PAGES

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Q1 (a) Name **TWO (2)** conditions or scenarios on a highway that can create 'shock waves' phenomenon in the traffic stream.

(2 marks)

(b) The southbound approach of a signalised intersection carries a flow of 1000 veh/h/ln at a velocity of 50 km/h. The duration of the red signal indication for this approach is 15 sec. If the saturation flow is 2000 veh/h/ln with a density of 75 veh/ln, the jam density is 150 veh/km. With the aid of **FIGURE Q1(b)**:

(i) Calculate the length of the queue at the end of the red phase.

(6 marks)

(ii) Examine the speed of backward recovery wave velocity.

(2 marks)

(iii) Analyse the maximum queue length.

(2 marks)

(iv) Estimate the time it takes for the queue to dissipate after the end of the red indication.

(4 marks)

(c) A gap between two vehicles is one of the most important factor of a driver need to consider in making any manoeuvres on roadway. Explain **THREE (3)** important measures that involve the concept of gap acceptance.

(9 marks)

Q2 (a) Explain **TWO (2)** roles of road hierarchy in a road network and land use planning.

(4 marks)

(b) 'Mobility' refers to the movement of people and goods, meanwhile 'accessibility' refers to the ability to reach desired goods, services, activities and destinations. Mobility recognises both automobiles and transit modes. However, mobility tends to give less attention on non-motorised modes (NMN) or land use factors effects on the accessibility. Do you agree with this claim? Explain **FIVE (5)** reasons to support your answer.

(15 marks)

(c) On 18th March 2020, Malaysia Government has instructed Malaysian to follow the Movement Control Order (MCO) due to the uncontrolled spreading of COVID-19 virus worldwide. Therefore, this MCO has affected many aspects of individuals' life routines. One of the aspect is from transportation and travel perspectives. Then, on the 4th May 2020, the government introduces Conditional Movement Control Order (CMCO) in which some organisations are open to operate, resulting in many travels being made for various purposes including for working purposes.

Discuss **THREE (3)** Traffic Management Strategies (TMS) under the Work-Schedule Management Technique that has been recommended by the government in order to ensure the good traffic flow and also to control the spreading of the COVID-19 virus.

(6 marks)

Q3 The layout and traffic demand, in passenger car unit per hour (pcu/hr), of a four-leg intersection that is to be upgraded to a signalised intersection using a 4-phased signal system are shown in **FIGURE Q3**. The saturation flows and pedestrian volumes for the four approaches are provided in **Table Q3**. The following information is also given:

All red interval (R)	= 2 sec
Yellow interval per phase (τ)	= 4 sec
Lost time per phase (l)	= 3 sec
Desired critical volume-capacity ratio (X_c)	= 0.85
Effective pedestrian crosswalk width (W_E)	= 2.5 m
Pedestrian crosswalk length (L)	= 15 m
Average pedestrian speed (S_P)	= 1.24 m/s

(a) Propose a suitable cycle time (C) using the methodology recommended by Highway Capacity Manual (HCM).

(13 marks)

(b) Determine the actual green time (G_a) for each phase.

(4 marks)

(c) Examine whether the minimum green times required for pedestrian crossing (G_p) are sufficient or not.

(8 marks)

Q4 (a) The performance of a 1.5 km of divided four-lane principal arterial with two signalised intersections at spacing of 800 m and 600 m is analysed. The green times are 35 sec and 40 sec respectively. The following information is provided and also refer to **Table Q4(a)(i) to Table Q4(a)(v)**:

Speed limit	= 70 km/h
Traffic volume (v)	= 1095 veh/h
Saturation flow (s)	= 1,950 pc/h/ln
Signal type	= Pretimed
Arrival type	= Type 3
Initial queue delay (d_3)	= 0 sec

Cycle length (C)	= 120 sec
Analysis period (T)	= 0.25 hours

(i) Determine the class and free flow speed of the arterial.

(3 marks)

(ii) Calculate the capacity (c), degree of saturation (X) and running time (T_R) for each segment.

(10 marks)

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

(12 marks)

- END OF QUESTIONS -

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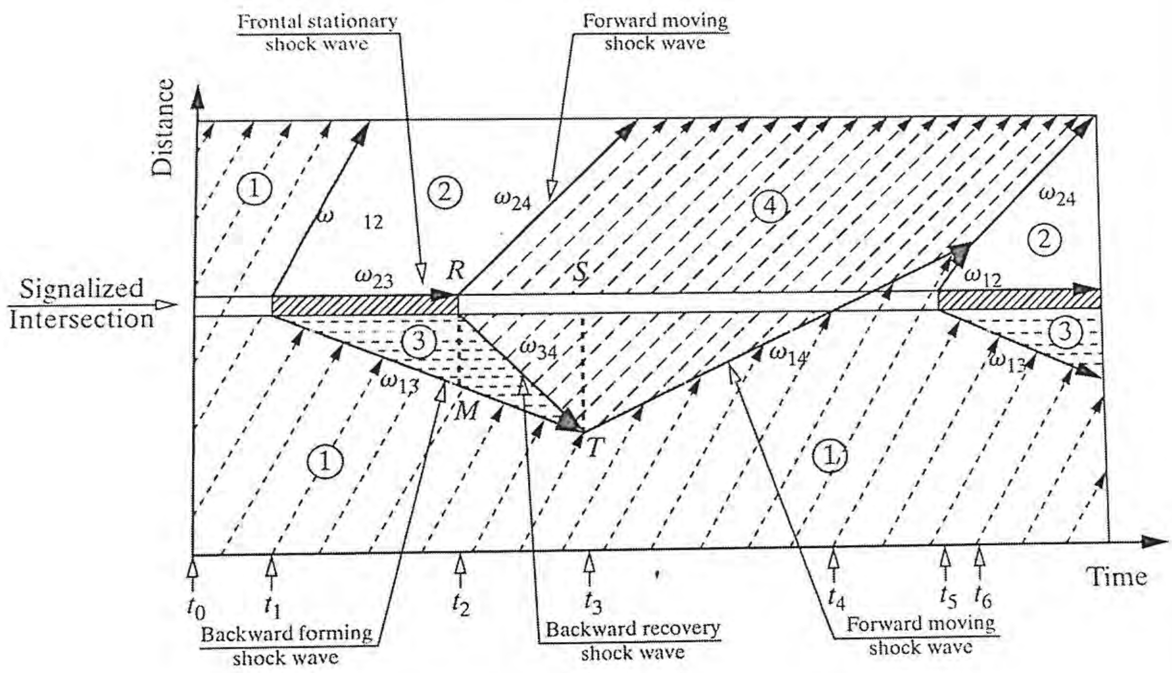

FIGURE Q1(b): Shock wave at signalised intersection

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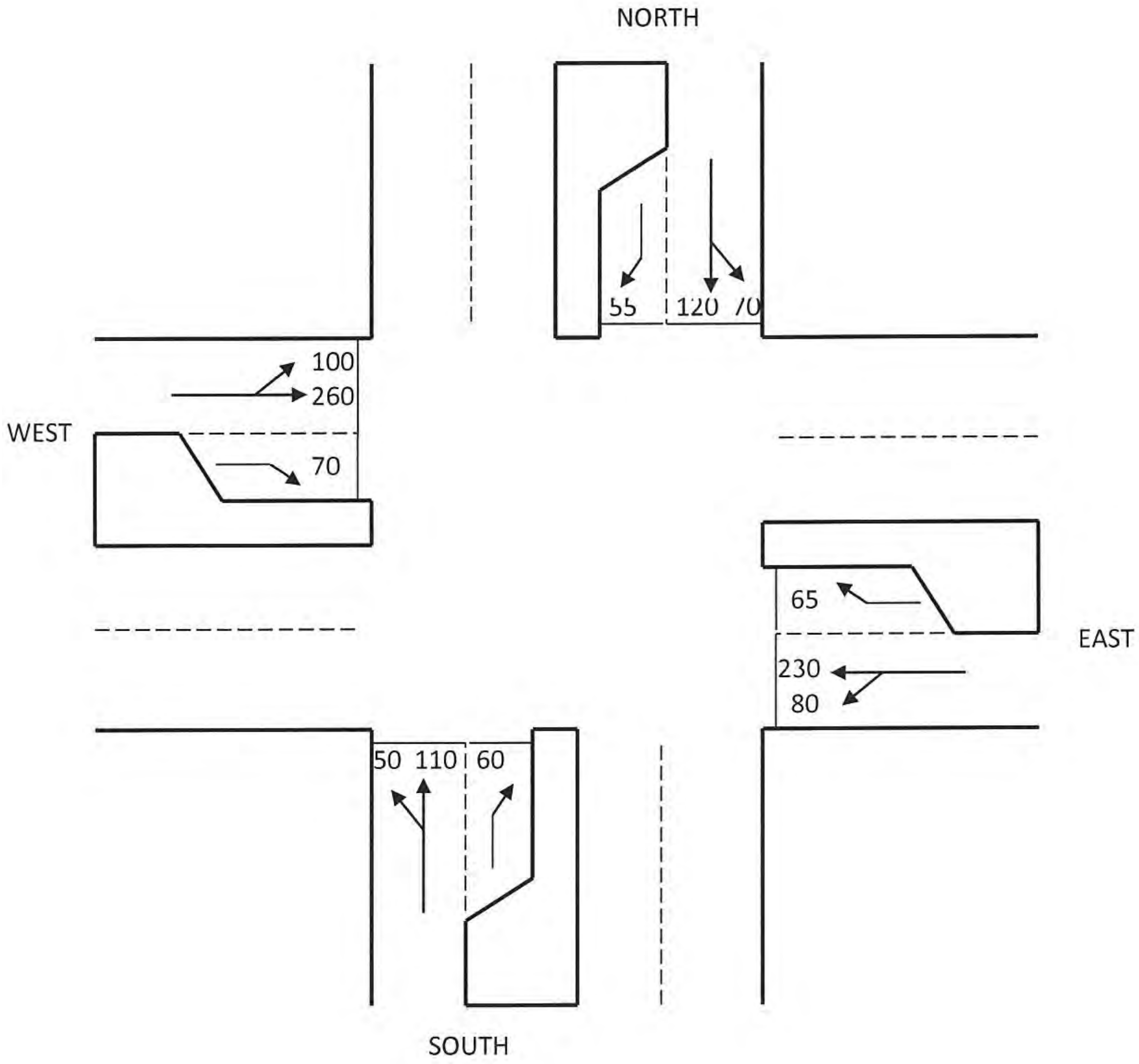

FIGURE Q3: Layout and traffic demand (pcu/hr) of the four-leg intersection

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Table Q3: Saturation flows and pedestrian volumes on the approaches

Phase	1		2		3		4	
Approach	West		East		North		South	
Movement	Through + Left	Right	Through + Left	Right	Through + Left	Right	Through + Left	Right
Saturation Flow [a]	1860	1070	1790	1090	1670	1100	1730	1060
Number of Pedestrians Crossing [b]	38		33		30		24	

Note: a The unit for saturation flow is passenger car unit/hour .
b The unit for number of pedestrians crossing is pedestrians/interval/direction.

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Table Q4(a)(i): Urban street class based on functional and design categories (HCM, 2000)

Design Category	Functional Category	
	Principal Arterial	Minor Arterial
High-Speed	I	N/A
Suburban	II	II
Intermediate	II	III or IV
Urban	III or IV	IV

Table Q4(a)(ii): Functional and design categories (HCM, 2000)

Criterion	Functional Category	
	Principal Arterial	Minor Arterial
Mobility function	Very important	Important
Access function	Very minor	Substantial
Points connected	Freeways, important activity centers, major traffic generators	Principal arterials
Predominant trips served	Relatively long trips between major points and through-trips entering, leaving, and passing through the city	Trips of moderate length within relatively small geographical areas

Criterion	Design Category			
	High-Speed	Suburban	Intermediate	Urban
Driveway/access density	Very low density	Low density	Moderate density	High density
Arterial type	Multilane divided; undivided or two-lane with shoulders	Multilane divided; undivided or two-lane with shoulders	Multilane divided or undivided; one-way, two-lane	Undivided one-way, two-way, two or more lanes
Parking	No	No	Some	Significant
Separate left-turn lanes	Yes	Yes	Usually	Some
Signals/km	0.3–1.2	0.6–3.0	2–6	4–8
Speed limit	75–90 km/h	65–75 km/h	50–65 km/h	40–55 km/h
Pedestrian activity	Very little	Little	Some	Usually
Roadside development	Low density	Low to medium density	Medium to moderate density	High density

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Table Q4(a)(iii): 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 Q4(a)(iv): 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 Q4(a)(v): 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.

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The following equations may be useful to you:

$$\omega_{12} = \frac{q_2 - q_1}{k_2 - k_1} = \frac{q_1 - q_2}{k_1 - k_2} = \frac{q_1 - 0}{k_1 - 0} = u_1 \qquad \omega_{13} = \frac{q_1 - q_3}{k_1 - k_3} = \frac{q_1 - 0}{k_1 - k_j} = \frac{q_1}{k_1 - k_j}$$

$$\omega_{23} = \frac{q_2 - q_3}{k_2 - k_3} = \frac{0 - 0}{0 - k_j} = \frac{0}{k_j} = 0 \qquad \omega_{24} = \frac{q_2 - q_4}{k_2 - k_4} = \frac{0 - q_4}{0 - k_4} = u_4$$

$$\omega_{34} = \frac{q_3 - q_4}{k_3 - k_4} = \frac{0 - q_4}{k_j - k_4} = \frac{-q_4}{k_j - k_4} \qquad \omega_{34} = \tan\gamma = \frac{\overline{ST}}{\overline{RS}}$$

$$Length\ of\ queue\ at\ the\ end\ of\ the\ red\ signal = r \times \omega_{13} = \frac{rq_1}{k_1 - k_j}$$

$$\overline{ST} = \frac{r\omega_{13}\omega_{34}}{\omega_{34} - \omega_{13}} \qquad \overline{RS} = (t_3 - t_2) = \frac{r\omega_{13}}{\omega_{13} - \omega_{34}}$$

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

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

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

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

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

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

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The following equations may be useful to you:

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

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

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

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

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

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