UNIVERSITI TEKNOLOGI MALAYSIA
Faculty of Civil Engineering

FINAL EXAMINATION
SEMESTER 1, SESSION 2018/2019

COURSE CODE	:	SKAA3842 / SAB3842
COURSE	:	TRAFFIC ENGINEERING
PROGRAMME	:	SKAW
DURATION	:	2 HOURS
DATE	:	DECEMBER 2018

INSTRUCTION TO CANDIDATES:

1. ANSWER ANY FOUR (4) QUESTIONS.
2. WRITE YOUR NAME, SECTION AND LECTURER'S NAME ON THE FRONT PAGE OF EVERY ANSWER'S BOOKLET.
3. YOU ARE NOT ALLOWED TO REFER TO ANY NOTE

<u>WARNING</u>!

Students caught copying/cheating during the examination will be liable for disciplinary actions and the faculty may recommend the student to be expelled from the study.

This examination question consist of (9) printed pages only.

Q1. (a) A student recorded the following traffic counts of vehicles travelling in a suburban roadway as shown in Table Q1(a). Describe briefly the differences between traffic volume and rate of flow. Then determine:

(i) The hourly volume.

(ii) The peak rate of flow for a 5-minute period within the hour.

(iii) The peak rate of flow for a 15-minute period within the hour.

(iv) The lowest volume for 10 minute interval.

Table Q1(a)

Time	Vehicle Number	Time	Vehicle Number
8:35-8:40 A.M.	101	9:05-9:10 A.M.	107
8:40-8:45 A.M.	105	9:10-9:15 A.M.	107
8:45-8:50 A.M.	116	9:15-9:20 A.M.	130
8:50-8:55 A.M.	122	9:20-9:25 A.M.	103
8:55-9:00 A.M.	130	9:25-9:30 A.M.	107
9:00-9:05 A.M.	121	9:30-9:35 A.M.	105

(10 marks)

(b) Traffic surveys have been conducted on two urban road segments for a period of 2 hours and 30 minutes. The summary of the data is given in Table Q1(b). If the passenger car equivalent value for small van is 2.00, medium lorry is 2.50, large truck and bus are 3.00 and motorcycle is 0.75, analyse the data and:

(i) Determine average hourly traffic volume at both locations in term of veh/h.

(ii) Express the average hourly traffic volume in terms of pcu/h.

(ii) Compare traffic flow conditions at both locations.

(iv) State the reason(s) for converting traffic volume in veh/h to pcu/h.

Table Q1(b)

Type of vehicles	Number of vehicles	
	Location 1	Location 2
Passenger car & taxi	900	800
Small van	30	100
Medium Lorry	20	20
Large truck	70	50
Bus	50	60
Motorcycle	250	150

(15 marks)

(25 marks)

Q2. (a) The relation between flow and density, density and speed, speed and flow, can be represented with the help of some curves. Interpret the relationship shown in Figure Q2(a) below and explain why in the stable flow region speed decreases as flow increases and in the unstable flow region speed decreases while at the same time flow also decreases?.

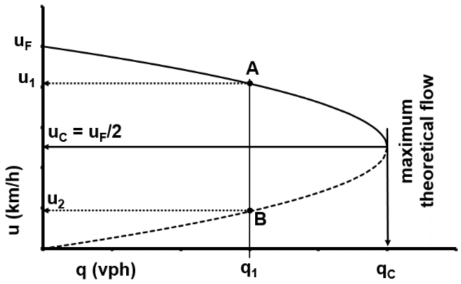

Figure Q2(a)

(10 marks)

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(b) A journey time study using a moving observer method was carried out on a 9 km segment of urban street shown in Figure Q2(b). The summary of data obtained for six numbers of tests is given in Table Q2. Determine:

(i) Average journey speed of traffic stream in km/h.

(ii) Average running speed of traffic stream in km/h.

(iii) Average delay based on journey speed if the speed limit is 60 km/h.

(iv) Comment on the differences between the two values of the journey speed and running speed.

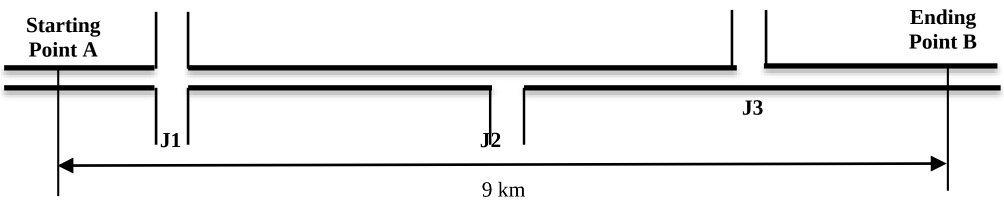


Figure Q2(b)

Table Q2

Test No.	Starting time of test car at Point A	Arrival time of test car at Point B	Stop delay at each junction (minutes)		
			J1	**J2**	**J3**
1	2:00:00 pm	2:25:00 pm	6	3	6
2	3:00:00 pm	3:32:00 pm	8	6	4
3	4:10:00 pm	4:10:00 pm	6	2	5
4	4:45:00 pm	4:30:00 pm	4	4	5
5	5:30:00 pm	5:10:00 pm	4	5	3
6	6:30:00 pm	6:55:00 pm	5	4	6

(15 marks)

(25 marks)

Q3. Table Q3 provides the spot speed data collected at residential area in Temerloh on weekdays.

(a) Determine the probability of having speeds between 70 km/h and 85 km/h.

(b) Determine the probability that the speeds exceed 55 km/h.

(c) Predict the median speed for this area.

(d) Explain the disadvantage if the speed limit is set far below the 85th percentile speed.

(e) Compare the spot speed samples collected from this area with the minimum required sample at 95% confidence level if maximum allowable error is 1.4 km/h and give your comment (s).

Table Q3

Speed class (km/hr)	Median of speed class (km/hr)	Frequency (f_i)
30-34.9	32.5	4
35-39.9	37.5	11
40-44.9	42.5	13
45-49.9	47.5	20
50-54.9	52.5	43
55-59.9	57.5	44
60-64.9	62.5	18
65-69.9	67.5	15
70-74.9	72.5	10
75-79.9	77.5	4

(25 marks)

Q4. (a) One way to reduce number of conflict points at intersections is by installing the traffic signal system.

(i) Briefly explain the definition of conflict point at an intersection.

(ii) Illustrate the conflict points for T-intersection and four-arm intersection. Compare the number of crossing, merging and diverging conflict points.

(10 marks)

(b) Table Q4(b) shows a traffic flow data and inventory at a four-arm stop-controlled junction which requires a traffic signal control system.

Table Q4(b)

From	**NORTH (N)**			**SOUTH (S)**		
To	**E**	**S**	**W**	**W**	**N**	**E**
Q (veh/h)	230	700	170	300	550	190
Lane width (m)	7.0			7.0		

From	**EAST (E)**			**WEST (W)**		
To	**S**	**W**	**N**	**N**	**E**	**S**
Q (veh/h)	90	410	80	50	550	80
Lane width (m)	6.0			6.0		

(i) Suggest an appropriate number of phases and draw the traffic phase sequence for the given junction. Assume 1 veh = 1.0 pcu. State the reason(s) for the choice.

(ii) Determine the optimum cycle time and the green period for each traffic phase if all adjustment factors are equal to 1.0, all-red period = 2 sec/phase, amber period = 3sec/phase and starting delay = 2 sec/phase.

(iii) Draw the timing diagram for the proposed design.

(15 marks)

(25 marks)

Q5. (a) An existing horizontal curve on a highway has a radius of 150 m, which restricts the design speed for this section of the road to only 62% of the design speed of the highway. If the curve is to be improved so that the speed limit which is 10 km/h lower than the design speed can be imposed, determine the minimum radius of the new curve. Assume that the rate of super-elevation is 0.06 and side friction of 0.16 for both the existing curve and the new curve to be designed.

(10 marks)

(b) One of the UTM Traffic Engineering student is trying to test the braking ability of his car found that he needed additional 5.8 m to stop his car when driving downhill on a road of 6% grade than when driving downhill at the same speed along another road of 3% grade. If the coefficient of friction, f is 0.35:

(i) Determine the speed at which the student conducted his test.

(ii) Determine the distance travelled before the car comes to a stop on the 8% uphill grade if the student is travelling at the same speed, given his perception-reaction time is 2.5 seconds.

(iii) Discuss factors that affect braking distance.

(10 marks)

(c) Passing Sight Distance (PSD) is the minimum sight distance which will allow a driver to pass another vehicle without colliding with a vehicle in the opposing lane. Explain the elements/components of PSD with proper sketch.

(5 marks)

(25 marks)

EQUATIONS

The symbols indicate parameters usually used.

$$Q_{AB} = \frac{X_{AB} + (Y_1 - Y_2)_{AB}}{t_A + t_W}$$

$$t_{AB} = t_W - \frac{(Y_1 - Y_2)_{AB}}{Q_{AB}}$$

$$u = u_f - \left(\frac{u_f}{k_j}\right) \times k$$

$$q = k_j \times u - \left(\frac{k_j}{u_f}\right) \times u^2$$

$$q = u_f \times k - \left(\frac{u_f}{k_j}\right) \times k^2$$

$$\overline{V_i} = \frac{\sum (f_i V_i)}{\sum f_i}$$

$$SD = \sqrt{\left(\frac{\sum f_i V_i^2}{\sum f_i} - \left(\frac{\sum f_i V_i}{\sum f_i}\right)^2\right)}$$

$$\text{Perception Distance} = 0.28Vt$$

$$\text{Braking distance} = \frac{V^2 - u^2}{254(f \pm G)}$$

$$A = G_2 - G_1 \quad r = \frac{G_2 - G_1}{L}$$

$$Y_X = \frac{rx^2}{2} + G_1 x + Y_0$$

$$\frac{dY_X}{dx} = rx + G_1$$

$$R = \frac{V^2}{127(e + f)}$$

$$\alpha = \theta - 2\theta_P, \quad \theta_P = 57.3\frac{L_P}{2R}$$

Length of circular segment, $L_B = R \times \frac{2\pi\theta}{360}$

Length of transition curve, $L_P = \frac{V^3\left(1 - \frac{R.g.e}{V^2}\right)}{c.R}$

$$L = \frac{AS^2}{2\left(\sqrt{h_1} + \sqrt{h_2}\right)^2}$$

$$L = 2S - \frac{2\left(\sqrt{h_1} + \sqrt{h_2}\right)^2}{A}$$

$$S_R = \frac{b}{\left(1 + \frac{1.524}{r}\right)}$$

b = 1800 for single lane
b = 3000 for two lanes

I = R + a, S = 525W

$$a = \frac{V}{2A} + \frac{W' + L'}{V} \quad y_i = \frac{q_i}{S_i}$$

$$Y = \sum_{i=1}^{n} y_i \qquad L = \sum_{i=1}^{n} R_i + \sum_{i=1}^{n} l_i$$

$$N = \left(\frac{z\sigma}{d}\right)^2 \quad z = \frac{(x - \mu)}{\sigma}$$

Optimum Cycle Time, $C_O = \frac{1.5L + 5}{1 - Y}$

Effective green, $g_i = \frac{y_i}{Y}(C_O - L)$

Actual green time $G_i = g_i + l + R$

Controller green time $K_i = g_i + l - a$

Table 1: Saturation flow for lane width equal to 5.5 m or less

W	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00	5.25
S	1845	1860	1885	1915	1965	2075	2210	2375	2560	2760

Table 2: Adjustment factors for the effects of gradient

Adjustment factor, Fg	Conditions
0.85	for upgrade 5%
0.88	for upgrade 4%
0.91	for upgrade 3%
0.94	for upgrade 2%
0.97	for upgrade 1%
1.00	for flat road
1.03	for downgrade 1%
1.06	for downgrade 2%
1.09	for downgrade 3%
1.12	for downgrade 4%
1.15	for downgrade 5%

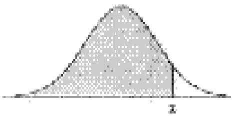
Table 3: Adjustment factors for turning radius effects

Adjustment factor, Ft	Conditions
0.85	for turning radius, $R < 10m$
0.90	for turning radius where$10m \leq R < 15m$
0.96	for turning radius where $15m \leq R < 30m$

Table 4: Adjustment factors for the effects of turning movements

% turning traffic	Factor for right-turn, Fr	Factor for left-turn, Fl
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

Tables of the Normal Distribution



Probability Content from -oo to Z

Z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2.0	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980	0.9981
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
3.0	0.9987	0.9987	0.9987	0.9988	0.9988	0.9989	0.9989	0.9989	0.9990	0.9990