King Mongkut's University of Technology Thonburi

Midterm Examination

Semester 1 Academic Year 2013

CVE 473 Traffic Engineering — 4th Year International Program in Civil Engineering

Date: 26th September, 2013 — Time: 13:00 – 16:00

Instruction:

1. You have 3 hours to finish the examination.
2. There are total of 10 problems with the total score of 100. The score distribution is shown in the individual problem.
3. To receive full credit, correct answers and all calculation steps should be shown.
4. Only the calculator approved by KMUTT and dictionary are allowed in the examination room.
5. This is a close-book exam. You should not consult with or disclose the content of this examination to any person.
6. You are prohibited to bring any part of this examination or your answers out of the examination room.

ANY CHEATING CAUGHT DURING THE EXAMINATION WILL BE PENALIZED TO THE FULLEST EXTENT PROSCRIBED IN THE KMUTT POLICY

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Instructor

This examination has been approved by the Department of Civil Engineering.

(Prof. Dr. Chai Jaturapitakkul)
Department Head

Name_____Student ID_____

Given useful equations:

$$\frac{d\theta}{dt} = \frac{vw}{w^2 + x^2}$$

$$v = v_0 + at$$

$$x = v_0 t + \frac{1}{2}at^2$$

$$x = \frac{1}{2a}(v^2 - v_0^2)$$

$$v = \frac{\alpha}{\beta}\left(1 - e^{-\beta t}\right) + v_0 e^{-\beta t}$$

$$x = \frac{\alpha}{\beta}t - \frac{\alpha}{\beta^2}\left(1 - e^{-\beta t}\right) + \frac{v_0}{\beta}\left(1 - e^{-\beta t}\right)$$

$$\frac{dv}{dt} = (\alpha - \beta v_0)e^{-\beta t}$$

$$D_b = \frac{{v_2}^2 - v_1^2}{254\left(\frac{a}{g} \pm G\right)} \text{ or } D_b = \frac{{v_2}^2 - v_1^2}{254(f \pm G)}$$

$$SSD = 0.278vt + \frac{v^2}{254\left(\frac{a}{g} \pm G\right)}$$

$$SSD = 0.278vt + \frac{v^2}{254(f \pm G)}$$

$$F = \frac{Wv^2}{2gd}$$

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

$$\frac{a}{g} - e = \frac{T}{2H}$$

$$d_1 = 0.278t_1\left(u - m + \frac{at_1}{2}\right)$$

$$d_2 = 0.278ut_2$$

$d_4 = 2/3d_2$

$$\bar{u} = \frac{\sum u_i}{N}$$

$$S = \sqrt{\frac{\sum(u_j - \bar{u})^2}{N-1}} \text{ or } S = \sqrt{\frac{\sum f_i(u_i - \bar{u})^2}{N-1}}$$

$$N = \left(\frac{Z\sigma}{d}\right)^2$$

$$\bar{u}_t = \frac{1}{n}\sum u_i$$

$$\bar{u}_s = u_f\left(1 - \frac{k}{k_j}\right)^n$$

$$\frac{d\bar{u}_s}{dk} = u_0 k^{(n-1)/2}$$

$$\bar{u}_s = u_f e^{-\frac{1}{2}(k/k_m)^2}$$

$$\bar{u}_s = \frac{n}{\sum_{i=0}^{n}\left(\frac{1}{u_i}\right)}$$

$$\bar{u}_t = \bar{u}_s + \frac{\sigma_s^2}{\bar{u}_s}$$

$$\bar{u}_s = \bar{u}_t - \frac{{\sigma_t}^2}{\bar{u}_t}$$

$$N = \left(\frac{t_\alpha \times \sigma}{d}\right)^2$$

$$V_{B-A} = \frac{(N_{A-B} + O_{B-A} - P_{B-A}) \times 60}{T_{A-B} + T_{B-A}}$$

$$\bar{T}_{B-A} = T_{B-A} - \frac{60(O_{B-A} - P_{B-A})}{V_{B-A}}$$

DHV = ADT x K

$$K = \frac{DHV}{ADT} \times 100\%$$

$$N = \frac{DDHV}{SF} = \frac{D \times DHV}{SF} = \frac{D \times K \times ADT}{SF}$$

$$PHF = \frac{V_{60}}{4 \times V_{15}}$$

$$Peak\ Flow\ Rate = \frac{DDHV}{PHF}$$

$$q = \frac{n \times 3600}{T}$$

$$q = k\overline{u_s}$$

$$\overline{u_s} = q\bar{d}$$

$$k = q\bar{t}$$

$$\bar{d} = \overline{u_s}\bar{h}$$

$$\overline{u_s} = q\bar{d}$$

$$k = q\bar{t}$$

$$\bar{d} = \overline{u_s}\bar{h}$$

$$\bar{h} = \bar{t}\bar{d}$$

$$q = ku_f - \frac{k^2 u_f}{k_j}$$

$$\bar{u}_s = u_f - \frac{u_f}{k_j}k$$

$$\bar{u}_s = c\ln\frac{k_j}{k}$$

$$\bar{u}_s = u_f e^{-(k/k_m)}$$

Name_____Student ID_____

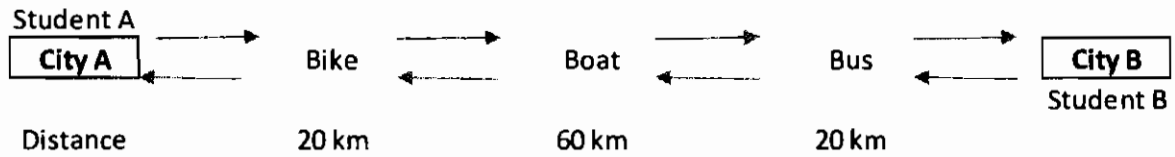
1. (5 pts.) What are major differences between Traffic Engineering and Transportation Engineering in terms of their focused travel modes and operating facilities?

2. (10 pts.) What are the mode, median, time mean speed, space mean speed, and the 85th percentile speed of the following speed data? (You must answer to all the underlined terms to receive full score)

   65 72 58 74 65 66 74 69 74 70

Name_____Student ID_____

3. (10 pts.) Two students leaving from their home city have to leave their home the same time at 5.00 AM and travel 100 km between the two cities. The student A has to travel from City A to City B. And the student B has to travel from City B to City A. There is only 1 route in and out for both cities. Both students have to use 3 modes of transportation due to geographical constrains and limited transportation modes on this route as shown in sequence below:



Each mode that the students A and B will use has different operating speeds as shown below:

Student A	Student B
Bike = 10 km/hr Boat = 30 km/hr Bus = 55 km/hr	Bike = 12 km/hr Boat = 28 km/hr Bus = 60 km/hr

Using time-space diagram technique to answer all of the following questions.

a. At what time the two students will meet each other along their travel?
b. Of which mode of travel that the two students will meet?
c. And where will be the meeting location (e.g. distance from either City A or B)?

Name_____Student ID_____

4. (10 pts.) Please identify for the suitable physical location of the road that you would install or use the following instruments to collect traffic volume, speed, and/or delay data. (Answer all)
    a. Road tube
    b. Radar gun
    c. Loop detector
    d. Speeding camera
    e. Manual counter
    f. License plate recognition camera
    g. Bluetooth reader

Name_____Student ID_____

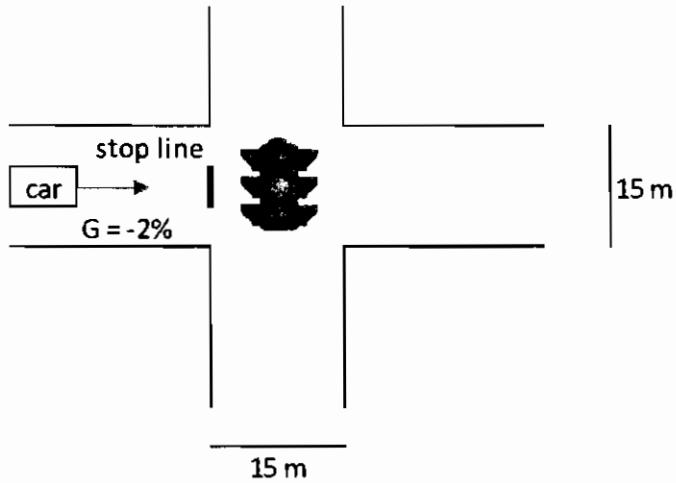
5. (10 pts.) Under what purposes or situations that you will need the following traffic count methods? (Answer all)
    a. Screen line counts
    b. Cordon counts
    c. Intersection counts
    d. Segment counts

6. (5 pts.) Describe the key difference between "Average Annual Daily Traffic (AADT)" and "Average Daily Traffic (ADT)."

7. (5 pts.) Explain how "Headway" and "Gap" between the 2 cars can be measured?

Name_____Student ID_____

8. (20 pts.) A 6-meter long vehicle approaches a signalized intersection at 60 kph. The PIEV time of the driver of the vehicle is 2.5 seconds. The acceleration and deceleration rates of this vehicle are the same at 2.31 m/s^2. The intersection is 15 meters in length as well as width. The grade for the traveling direction is 2% downhill. The yellow time is 3 seconds. At the beginning of yellow time, the driver has to make a decision either to stop by braking or pass the intersection by maintaining the same speed. Answer all of the following questions:



   a. If the driver decide to stop, what would be the stopping sight distance (SSD) required for the vehicle to come to a full stop at the stop line?
   b. On the other hand, if the driver decide to pass the intersection, how far (in meter unit) from the stop line can the vehicle be at the beginning of yellow time, so it can clear the intersection by the end of the yellow time? (To clear the intersection, entire length of the vehicle must pass the corner of the far end of the intersection)

Name_____Student ID_____

9. (15 pts.) The data shown below were collected on a highway.

Speed (kph)	Density (veh./km)
16	85
25	70
30	55
45	41
55	20
60	15

A traffic engineer uses regression analysis to fit these data to the Greenshields model using the linear regression form of $y = a + bx$. It was determined using a computer software spreadsheet that $a = 68.50$ and $b = -0.63$. Find answers to all of the following questions:

a. Mean free flow speed
b. Jam density
c. Maximum capacity
d. Speed at maximum flow

Name_____Student ID_____

10. (10 pts.) A two-lane rural highway has a posted speed limit of 70 kph. The local traffic engineer conducted a speed study of the subject road and found the following:

    Average speed of the passing vehicle was 70 kph

    Average acceleration of the passing vehicle was 2.3 km/h/sec.

    Average speed of impeder vehicles was 60 kph

    Average time for initial maneuver, occupation of passing lane, and the minimum clearance between the passing vehicle and the opposing vehicle follow the AASHTO guide below for the nearest passing speed:

Component of passing maneuver	Metric				US Customary			
	Speed range (km/h)				Speed range (mph)			
	50–65	66–80	81–95	96–110	30–40	40–50	50–60	60–70
	Average passing speed (km/h)				Average passing speed (mph)			
	56.2	70.0	84.5	99.8	34.9	43.8	52.6	62.0
Initial maneuver:								
a = average acceleration[a]	2.25	2.30	2.37	2.41	1.40	1.43	1.47	1.50
t_1 = time (sec)[a]	3.6	4.0	4.3	4.5	3.6	4.0	4.3	4.5
d_1 = distance traveled	45	66	89	113	145	216	289	366
Occupation of left lane:								
t_2 = time (sec)[a]	9.3	10.0	10.7	11.3	9.3	10.0	10.7	11.3
d_2 = distance traveled	145	195	251	314	477	643	827	1030
Clearance length:								
d_3 = distance traveled[a]	30	55	75	90	100	180	250	300
Opposing vehicle:								
d_4 = distance traveled	97	130	168	209	318	429	552	687
Total distance, $d_1 + d_2 + d_3 + d_4$	317	446	583	726	1040	1468	1918	2383

[a] For consistent speed relation, observed values adjusted slightly.

Note: In the metric portion of the table, speed values are in km/h, acceleration rates in km/h/s, and distances are in meters. In the U.S. customary portion of the table, speed values are in mph, acceleration rates in mph/sec, and distances are in feet.

Calculate the required minimum passing sight distance.