CE740 (3 0 1 8) - Traffic Engineering

Home Work

November 1, 2018

Written Assignments

Instructions All questions and answers must be hand written. Start new question on a new page with the question code on the top. Use a dedicated note book for the purpose of assignments. This note book along with the class notes can used for quizes. Descriptive questions should be rich in figures/tables/equations along with appropriate references (books/journals). Student shall do their assignments independently. Assignment will checked randomly by TA/Instructor.

1. An observer standing beside a road starts counting vehicle passing him from 4pm to 4:20pm and he counts about 580 vehicles. What is the average time headway. Deadline *Sep 07*.

2. Verify the relationship between the time mean speed and space mean speed using some hypothetical speed data generated by you (about 20-30 spot speeds) and represented in a frequency table. Deadline *Sep 07*.

3. For the data given below,compute the time mean speed and space mean speed. Also verify the relationship between them. Finally compute the density of the stream.

Speed range	Frequency
1-4	5
5-8	15
9-12	23
13-16	24
17-20	16

   Deadline *Sep 07*.

4. In a traffic study, the observed densities were 150, 120, 50, 70 and 20 veh/km and the corresponding speeds were 10, 25, 45, 40 and 32km/h. Find the jam density according to Greenberg's logarithmic traffic stream model. (Hint: Linearize the expression) Deadline *Sep 07*.

5. The following speed and density is observed from a road section. If we assume the speed decreases linearly with respect to density, then: (a) what will be the density at a speed of 10 kmph, and (b) what will be the maximum flow across the section

Speed (kmph)	Density (veh/km)
5	120
20	90
30	40
40	10

Deadline *Sep 07*.

6. Derive the expression for flow across a section of road by moving car method. Prove that this formulae actually estimates the stream flow. Deadline *Sep 07*.

7. In a traffic stream, 30% of the vehicles travel at a constant speed of 60km/h, 30% at a constant speed of 80km/h, and the remaining vehicles at a constant speed of 100km/h. An observer travelling at a constant speed of 70km/h with the stream over a length of 5km is overtaken by 17 vehicles more than what he has overtaken. The observer met 303 vehicles while traveling against the stream at the same speed and over the same length of highway. What is the mean speed and flow of the traffic stream? Deadline *Sep 07*.

8. Two friends were traveling from Mumbai to Pune and have decided to count the vehicles on a short stretch of 5 km. The first one sat on the left side and counted vehicles passed by him. The second sat on the right side and counted vehicles overtaken him. They counted 20 and 60 respectively while traveling at 30 kmph. They did the same exercise on the next day about same time and counted 25 and 40 respectively and were traveling at 35 kmph. Assuming same traffic conditions on both days, compute the density, mean speed, and flow on that stretch. Deadline *Sep 07*.

9. The table below shows spot speed data (in meters/sec) and the projected area (PA) of each vehicle type (in square meters) from a study. Find the PCU value of each vehicle type using Chandra's method.

No	Car	3W	2W	HCV
PA	5.39	4.48	1.20	24.74
1	11.32	8.67	6.67	7.4
2	6.74	7.25	8.27	6.09
3	11.11	9.68	7.75	5.88
4	6.67	6.98	6.12	6.38
5	8.11	8.77	9.52	5.66
6	7.41	8.77	11.9	5.66
7	8.11	9.52	6.97	5.55

Deadline *Sep 07*.

10. Cars, bikes, auto-rickshaws, and buses are moving in a traffic stream with means speeds of 10, 9, 8, and 7 m/sec. Further, the proportion of these vehicles among the 3000 vehicles counted in an hour is found to be 40, 30, 20, 10 per cent respectively. Compute the flow rate in passenger car units if the equivalency concept proposed by Chandra is adopted. Make suitable assumptions if required. Deadline *Sep 07*.

11. For a given road following speed data is collected. 25, 31, 36, 39, 42, 44, 47, 48, 49, 51, 52, 52, 53, 54, 55, 56, 57, 57, 57, 58, 59, 60, 60, 62, 63, 64, 65, 66, 66, 68, 68, 69, 70, 70, 71, 73, 75, 79, 85, 89, 90. What is the speed you will recommend for designing sight distance or radius of circular curve? Deadline *Sep 07*.

12. Classify with one example the various detections technologies with a brief mention of the merits and demerits of the system. Deadline *Sep 07*.

13. It was observed that the inductive loop was on for 0.39, 0.46, 0.43, 0.47, 0.50, 0.51, 0.48, 0.46, 0.32, 0.44, 0.50, 0.45, 0.44 seconds during one minute interval. If the effective length of a vehicle is 7 meters, compute the density Deadline *Sep 07*.

14. Write brief notes on the working principle, merits, and demerits of: (i) Video image detection, (ii) Infrared sensors, (iii) Microwave - Doppler and Radar, (iv) Pulsed and active ultrasonic, and (v) Passive acoustic array Sensors. Deadline *Sep 07*.

15. Describe how probe vehicle is used to collect traffic data highligting the kind of data and merits and de-merits of the technology. Deadline *Sep 07*.

16. In the absense of any automated equipments, how would you conduct a survey to get travel time data in a stretch of road. Deadline *Sep 07*.

17. An observer counts 300 vehicles in an hour at a location. Assuming that the vehicle arrival follows Poisson distribution: (i) estimate the probability of a pedestrian getting a gap of at least 5 seconds; and (ii) estimate how many vehicles will be generated in two minutes (Assume 20 second interval and use the following random numbers: 0.60, 0.42, 0.54, 0.48, 0.69, 0.42) Deadline *Sep 07*.

18. If the flow rate at a given section of road is 1600 and if we assume the inter arrival time of vehicles follow an exponential distribution, then:

    (a) the probability of headways greater than 1.8 second

    (b) the probability of headway between 1.2 and 2.4 seconds

    (c) the probability of headways less than the mean headway

    Deadline *Sep 07*.

19. An obseravtion from 3424 samples is given table below. Mean headway observed was 3.5 seconds and the standard deviation 2.6 seconds. Fit a normal distrbution, if we assume minimum expected headway is 0.5.

    Deadline *Sep 07*.

20. A line of vehicles are in car following mode and all vehicles are travelling at 18 m/s with distance headway of 20 m. After 1.2 seconds, the lead vehicle suddenly decelerates at a rate of 1.2 m/s^2 until it stops completely. simulate the behaviour of first following vehicle using the GM fifth car following model for the first 2.5 seconds. Tabulate the results. Assume headway exponent 1.2, speed exponent 1.6, sensitivity coefficient 0.8, reaction time 0.6 seconds, and scan interval 0.3 seconds. Deadline *Sep 07*.

21. A car is travelling with a speed of 16 m/sec at time t=0. Another car follows the first at a distance of 28 m with same velocity. If the first car accelerated by 1 m/sec^2 from t=1 to 2 and decelerate by 1 m/sec^2 from t=2 to 3, find the speed, acceleration and spacing of the follower at time t=3.0 sec. Assume the reaction time is 1 sec, vehicle dynamics are updated every 0.5 seconds, and the car following model is given by Eq. **??**. (Use of a tabular form is encouraged).

$$a_{n+1}(t) = 15 \times \left[\frac{u_n(t-1) - u_{n+1}(t-1)}{x_n(t-1) - x_{n+1}(t-1)}\right] \tag{1}$$

    Deadline *Sep 07*.

22. A roadway has 3 lanes. A vehicle is travelling in the middle lane (i.e., 2nd) and has the options of either travelling in the same lane or changing either to the 1st or 3rd lanes. These decisions are governed by the utlities of the lanes (U_l) and gaps (U_g) . If the vehicle has decided to leave the current lane, the decisions of choosing among the

Table 1: Obsered headway distribution

h	h+dh	p_i^{obs}
0.0	0.5	0.012
0.5	1.0	0.064
1.0	1.5	0.114
1.5	2.0	0.159
2.0	2.5	0.157
2.5	3.0	0.130
3.0	3.5	0.088
3.5	4.0	0.065
4.0	4.5	0.043
4.5	5.0	0.033
5.0	5.5	0.022
5.5	6.0	0.019
6.0	6.5	0.014
6.5	7.0	0.010
7.0	7.5	0.012
7.5	8.0	0.008
8.0	8.5	0.005
8.5	9.0	0.007
9.0	9.5	0.005
9.5	$>$	0.033
Total		1.00

other two lanes are governed by the utilities of gaps (U_g) in those lanes. On which lane would the vehicle like to travel probably?

$U_l = 3.467 - 0.0757 \times Relativespeed - 0.0064 \times Frontgap$

$U_g = 5.567 - 0.03 \times Leadgap - 0.0129 \times Laggap$

Lane No.	Relative speed (m/s)	Front gap (m)	Lead gap (m)	Lag gap (m)
1	5	8	5	3
2	3	-	-	-
3	8	-	9	6

Deadline *Sep 07*.

23. A freeway meets an urban arterial. What kind of intersection control do you propose? Show the plan with the traffic movements. Deadline *Oct 05*.

24. Give few examples of *no control*. Deadline *Oct 05*.

25. Give one example (with neat sketch) each for traffic signs (i) for your own safety, (ii) for the safety of other road users, and (iii) not specifically for safety purposes. Deadline *Oct 05*.

26. With the help of neat diagrams show the traffic signs and road markings for (i) Ramp from an urban arterial joining the freeway, (ii) Rotary, (ii) Uncontrolled intersection joining a minor and major road, (iv) Signalized intersection. Deadline *Oct 05*.

27. (i) Illustrate with a neat sketch what traffic signs and road markings you propose at the entrance gate of your institute? (ii) Illustrate with a neat sketch no passing zone markings at a horizontal curve when the stopping sight distance is less than the radius of the curve (Assume the road is two lane bidirectional). Deadline *Oct 05*.

28. Channelize the intersection given in the Figure **??** with the help of a neat sketch. Show the paths of movements by short arrows. All the roads are bi-directional. Assume the flows are very high. Deadline *Oct 15*.

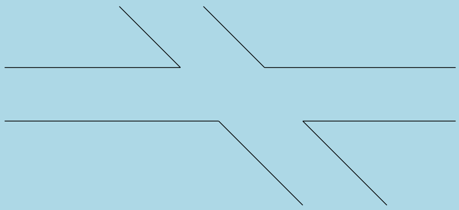

Figure 1: Intersection layout

29. The entry and exit width of a rotary intersection are 9m and 11m respectively. The width of approaches at the intersection is 15m. The traffic from the four approaches traversing the intersection is given below. If the traffic composition is 50% car, 40% two-wheelers and 10% trucks and the passenger car units of two-wheelers and trucks are 0.5 and 3 respectively, find the capacity of the rotary using TRL formulae. Dead-

Approach	Left turn	Straight	Right turn
North	500	800	300
South	400	350	450
East	250	400	500
West	300	450	500

line *Oct 15*.

30. Draw a neat sketch of a diamond interchange and mark all the traffic movements. Discuss the siuations where this is warrented. Deadline *Oct 15*.

31. Draw a neat sketch of a fully clover leaf intersection and mark all the traffic movements. Discuss the siuations where this is warrented. Deadline *Oct 15*.

32. A person standing at a stop line of signalized intersection found that the vehicles arrive at 3.7, 6.9, 9.7, 12, 14.1, 16, 17.9, and 19.8 seconds after the start of the green. The signal turns red at 20th second. Find the lost time, saturation flow and lane capacity. (Assume cycle is 60 second, amber is 3 s) Deadline *Oct 15*.

33. A person standing at a stop line of signalized intersection found that the vehicles arrive at 3.7, 6.9, 9.7, 12, 14.1, 16, 17.9, and 19.8 seconds after the start of the green. Find the lost time and saturation headway. Deadline *Oct 15*.

34. A major road with four lane running E-W direction meets a minor road having two lane running in N-S direction. The E-W flow is 1670, W-E flow is 1550, N-S flow is 720, and S-N flow is 680 vehicles per hour. The intersection of the two road is controlled by a traffic signal with a cycle time of 60 seconds. Assume for all the phases the yellow time is 3 seconds, the lost time is 4 seconds, and saturation headway is 2.1

seconds. Ignore turning movements and pedestrian traffic. Compute the green time for each phase and total delay experienced by all vehicles in the intersection for one hour duration. Deadline *Oct 15*.

35. The phase plan and flows of a signalised intersection are given in Fig. **??**. Assume for all the phases the yellow time is 4 seconds, lost time is 3 seconds, saturation headway is 2 seconds, and the degree of saturation x_c=0.9. Compute the cycle length C and green time for each phase. Show these in a phase-time diagram. Compute also the average delay per vehicle using Webster's model for each lane and also for the intersection D_I. Ignore pedestrian requirements. (Answer: C=73 sec, D_I=27.71 sec/veh.). Deadline *Oct 31*.

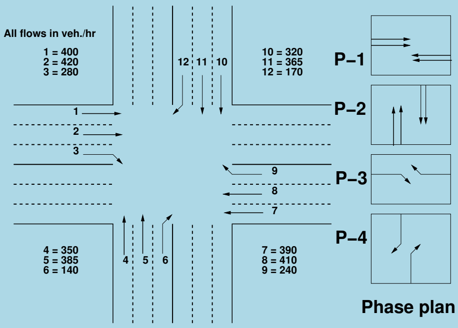

Figure 2: Intersection flows and phase plan

36. The phase plan and flows of a signalised intersection are given in Fig. **??**. The traffic flow and phase plan for a four arm intersection is given in Fig. **??**. Assume that for each phases the yellow time is 3 secconds, the lost time is 2.4 seconds, saturation headway is 2.2 seconds. The left turn and righ turn traffic proportions are 10%, 20%. The left and right lane utilisation factors for EW and WE approaches are 0.2, 0.1 respectively. For the NS, SN approaches assume equal distribution. The EW, WE, NS, SN apprach flows in vehicle per hour are respectively 800, 800, 400, 400. Assume a pedestrian phase with start up lost time of 4 sec, pedetrian walking speed of 1.2 m/sec, and lane width of 3.5 meters. Compute the cycle length, green times, lane delays, and intersection delays. (Answer: Cycle length 100 seconds and Intersection delay :40.47 seconds per vehicle.)

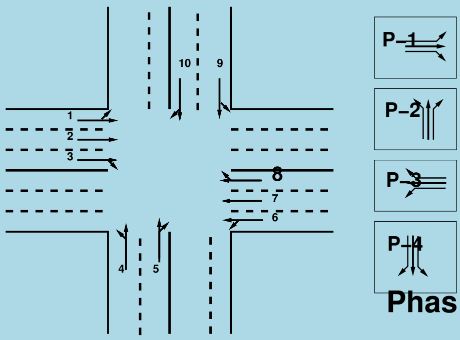

Figure 3: Intersection flows and phase plan

Solution Deadline *Oct 31*.

37. Calculate the delay and level of service using HCM method for a signalised intersection in South bound direction. Follow the terminology as per HCM 2000 and the intersection geometry is as shown in Figure **??**.

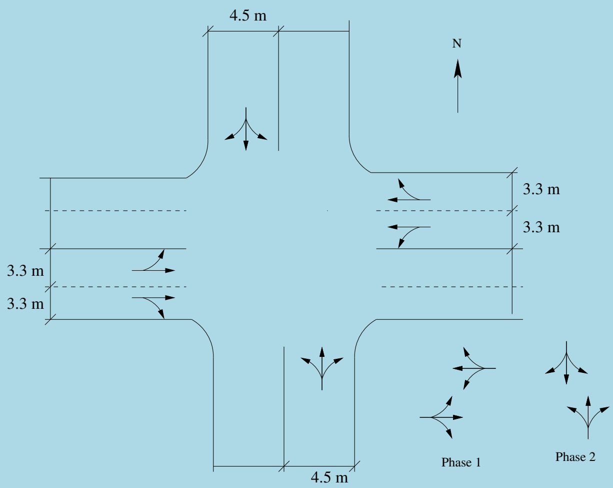

Figure 4: Intersection Geometry

The intersection is located in CBD area and the traffic volume in each direction in vehicles/hour is given as

	East bound	West bound	North bound	South bound
Left turn	65	30	30	40
Through	620	700	370	510
Right turn	35	20	20	50

Pedestrian volume = 100 pedestrains/hour,
Percentage of heavy vehicles = 5% in East and West approaches and 8% in North and South approaches,
Base saturation flow rate = 1900 veh/h/lane,
Peak hour factor= 0.9,
Cross walk width = 3.0 m,
North bound and South bound has two lanes, one in each direction of lane width 4.5m,
East bound and West bound has four lanes, two in each direction of lane width 3.3m.
Two phase signal with cycle time 70 seconds and North bound-South bound green time=36 s,
East bound-West bound green time =26 s,
Amber time= 4 s and Movement lost time =4 s,
Arrival type 4 and Analysis duration = 15 min,
Assume 0% grade with no parking maneuvers and no buses stopping.
Consider Lane utilisation adjustment factor in North and South approaches= 1.00, East and West approaches = 0.95.
Left turn pedestrian/bicycle adjustment factor= 0.999(N), 0.998(S), 0.997(E), 0.998(W),
Right turn pedestrian/bicycle adjustment factor= 0.996(N), 0.994(S), 0.992(E), 0.995(W),
Passenger car equivalent for heavy vehicle = 2.0,
Left turn adjustment factor is 0.937(N), 0.951(S), 0.716(E), 0.901(W).
Incremental delay factor= 0.5 and Initial queue delay= 0 s/veh.
Progression adjustment factor = 1.000. (SAME AS HCM2000 Example, but full) Deadline *Oct 31*.

38. The distance between two intersections is 0.75 km and the average vehicle speed in the northbound direction is 45 kmph and south bound direction is 50 kmph. If the cycle time is 90 seconds, split is 50 percent, and north bound and south bound traffic volume is 900 vehicles/hour, compute offset and band width, if: (a) only north bound traffic is considered, and (b) both directions are considered. Illustrate the result using time-space diagram. Deadline *Nov 05*.

39. Vehicles arrive at a toll booth at an average rate of 300 per hour. Average waiting time at a toll booth is 10 s per vehicle. Three options are considered: (i) M/M/1, (ii) M/M/2, and (iii) two M/M/1 system. If both arrival and departures are Markovian events, what is the average number of vehicles in the system, average queue length, average delay per vehicle, average time in the above systems? Deadline *Nov 05*.

40. On a 2.8 km long link of road, it was found that the vehicle demand was 1000 veh/hr, mean speed of the link 12 km/hr, and free flow speed 27 km/hr. Assuming the Average vehicle occupancy as 1.2 person/vehicle, calculate congestion intensity in terms of total person hours of delay. Deadline *Nov 05*.

41. (i) Derive the hyperbolic (explicit) form of LWR model using the following parameters in Greenshield's equation. Free flow speed is 80 kmph; Jam density is 320 veh/hr. (ii) Find the values of density at points (t=0.25 hr, x=15 km) and (t=1.0 hr, x=70 km) using the method of characteristics with the following initial condition:

$$k(x,0) = k_0(x) \begin{cases} 80\ veh/km & \text{if } 0 < x \leq 10\ km \\ 60\ veh/km & \text{if } 0 > 10\ km \end{cases} \tag{2}$$

Deadline *Nov 05*.