TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2080 Ashwin

Exam.	Regular		
Level	M.Sc.	Full Marks	60
Programme	MSTrE	Pass Marks	30
Year / Part	I / I	Time	3 hrs.

Subject: - Traffic Engineering

- Candidates are required to give their answers in their own words as far as practicable.
- *Attempt any Five questions.*
- *The figures in the margin indicate Full Marks.*
- *Necessary charts and tables are attached herewith.*
- *Assume suitable data if necessary.*

1. a) Define the following terms and give examples where they are used. [6]

   Peak Hour Factor (PHF)
   Space Mean Speed (SMS)
   Average Annual Daily Traffic (AADT)

   b) The parking garage at downtown CBD has 5 floors with 75 parking bays at each floor and open for commuters and shoppers from 9:00 am to 9:00 pm each weekday. The parking fee is NRs 400 to park all day and NRs. 50 per hour for short term parkers. In an average 250 commuters park each day. Recent parking survey estimated that average parking duration of shoppers is 3 hours. There is demand of 650 vehicles used by shoppers. Assume parking efficiency of commuters is 1.0 and that of shopper is 0.95. Calculate the average revenue generated per day, lost revenue due to parking shortage and additional parking spaces required to cater the parking demand. [6]

2. a) The northbound approach of a signalized intersection carries a flow of 1000 veh/h/ln at a speed of 50 kmph. The duration of the red signal indication for this approach is 15 sec. If the saturation flow is 2000 veh/h/ln with the density of 75 veh/ln, the jam density is 150 veh/km, determine the following: [6]

   i) The length of the queue at the end of red phase.
   ii) Speed of backward recovery shockwave.
   iii) The maximum queue length.

   b) What is clearance interval? Which parameters are important in determining this timing? [6]

3. a) An intersection had a four-phase signal with the movements allowed in each phase and corresponding analysis and saturations flow rates as shown in the table below. Calculate the minimum cycle length and the effective green times for each phase assuming lost time of 4 seconds per phase and a critical intersection v/c of 0.9. (Use Highway Capacity Formula) [6]

Phase	1	2	3	4
Allowed movements	EB R, WB R	EB T/L, WB T/L	SB R, SB T/L	NB R, NB T/L
Analysis flow rate (veh/h)	245, 230	975, 1030	255, 235	225, 215
Saturation flow rate (veh/h)	1750, 1725	3350, 3400	1725, 1750	1700, 1750

   b) Describe the type of information to be provided on a collision diagram. Explain why exposure-based crash rates are used. [6]

4. a) List and describe any four ITS user services that can enhance the use of public transportation in Kathmandu valley. [6]

   b) Determine the capacity of the lane group of one lane for the through movement if the effective green time for this movement is 35 seconds and total cycle time is 60 seconds under following conditions.
   Base saturation flow rate = 1900 pc/h/ln
   Lane width = 3.3 m
   Heavy vehicles = 4% of the traffic stream
   Approach grade = +3%
   No on street parking
   No bus stops
   Bicycle and pedestrian traffic conflicting with this lane group is negligible.
   Intersection is in a central business district. [6]

5. a) A highway designer would like to maintain the service flow rate for a 4-lane freeway segment designed in a mountainous terrain to have a maximum service flow rate of 1200 pcphpl. The designer intends to determine the percentage of recreational vehicles that will be allowed to use this freeway to keep the flow rate at this limit as the freeway leads to national park and camping areas. If the PHF is 0.90, the peak-hourly volume is 1700 veh/hr in one direction, and the drivers are assumed to be commuters, determine the percentage of recreational vehicles. No truck/buses are allowed to use the highway. [6]

   b) A 20 km long segment of class II two lane highway is in a recreational area of rolling terrain with the following characteristics: (Refer equations and charts provided) [6]

   Peak hour volume (two way) = 470 veh/hr
   Base free flow speed = 80 kmph
   Lane width = 3.3 m
   Shoulder width = 1.2 m
   80% no passing zones
   Directional split = 60/40
   5% trucks and 10 % RVs, 10% buses, 75% passenger cars
   PHF = 0.85
   12 access points per km
   Find the operating level of service of this highway during peak period.

6. Write short notes on: [4×3]
   a) Intersection control mechanism
   b) Vehicle actuated traffic signal system
   c) Congestion quantification

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Equations and Charts provided

Q.No. 4 (b)

Factor	Formula	Definition of Variables	Notes
Lane width	$f_w = 1 + \frac{(W-12)}{9}$	W = lane width (m)	W ≥ 2.4 If W > 4.8, a two-lane analysis may be considered
Heavy vehicles	$f_{HV} = \frac{100}{100 + \%HV(E_T - 1)}$	%HV = % heavy vehicles for lane group volume	E_T = 2.0 pc/HV
Grade	$f_g = 1 - \frac{\%G}{200}$	%G = % grade on a lane group approach	-6 ≤ %G ≤ +10 Negative is downhill
Parking	$f_p = \frac{N - 0.1 - \frac{18N_m}{3600}}{N}$	N = number of lanes in lane group N_m = number of parking maneuvers/h	0 ≤ N_m ≤ 180 f_p ≥ 0.050 f_p = 1.000 for no parking
Bus blockage	$f_{bb} = \frac{N - \frac{14.4N_b}{3600}}{N}$	N = number of lanes in lane group N_b = number of buses stopping/h	0 ≤ N_b ≤ 250 f_{bb} ≥ 0.050
Type of area	f_a = 0.900 in CBD f_a = 1.000 in all other areas		
Lane utilization	$f_{LU} = v_g/(v_{g1}N)$	v_g = unadjusted demand flow rate for the lane group, veh/h v_{g1} = unadjusted demand flow rate on the single lane in the lane group with the highest volume N = number of lanes in the lane group	

Q.No. 5 (a)

Factor	Type of Terrain		
	Level	Rolling	Mountainous
E_T (Trucks and Buses	1.5	2.5	4.5
E_R (RVs)	1.2	2.0	4.0

Q.No. 5 (b)

$$FFS = BFFS - f_{LS} - f_A \qquad PTSF = BPTSF + f_{d/np} \qquad BPTSF = 100\left(1 - e^{-0.000879 v_p}\right)$$

LOS	Percent Time-Spent-Following
A	≤ 40
B	> 40–55
C	> 55–70
D	> 70–85
E	> 85

Note:
LOS F applies whenever the flow rate exceeds the segment capacity.

	Reduction in FFS (km/h)			
	Shoulder Width (m)			
Lane Width (m)	≥ 0.0 < 0.6	≥ 0.6 < 1.2	≥ 1.2 < 1.8	≥ 1.8
2.7 < 3.0	10.3	7.7	5.6	3.5
≥ 3.0 < 3.3	8.5	5.9	3.8	1.7
≥ 3.3 < 3.6	7.5	4.9	2.8	0.7
≥ 3.6	6.8	4.2	2.1	0.0

Access Points per km	Reduction in FFS (km/h)
0	0.0
6	4.0
12	8.0
18	12.0
≥ 24	16.0

GRADE ADJUSTMENT FACTOR (f_G) TO DETERMINE PERCENT TIME-SPENT-FOLLOWING ON TWO-WAY AND DIRECTIONAL SEGMENTS

Range of Two-Way Flow Rates (pc/h)	Range of Directional Flow Rates (pc/h)	Type of Terrain	
		Level	Rolling
0–600	0–300	1.00	0.77
> 600–1200	> 300–600	1.00	0.94
> 1200	> 600	1.00	1.00

GRADE ADJUSTMENT FACTOR (f_G) TO DETERMINE SPEEDS ON TWO-WAY AND DIRECTIONAL SEGMENTS

Range of Two-Way Flow Rates (pc/h)	Range of Directional Flow Rates (pc/h)	Type of Terrain	
		Level	Rolling
0–600	0–300	1.00	0.71
> 600–1200	> 300–600	1.00	0.93
> 1200	> 600	1.00	0.99

PASSENGER-CAR EQUIVALENTS FOR TRUCKS AND RVS TO DETERMINE SPEEDS ON TWO-WAY AND DIRECTIONAL SEGMENTS

Vehicle Type	Range of Two-Way Flow Rates (pc/h)	Range of Directional Flow Rates (pc/h)	Type of Terrain	
			Level	Rolling
Trucks, E_T	0–600	0–300	1.7	2.5
	> 600–1,200	> 300–600	1.2	1.9
	> 1,200	> 600	1.1	1.5
RVs, E_R	0–600	0–300	1.0	1.1
	> 600–1,200	> 300–600	1.0	1.1
	> 1,200	> 600	1.0	1.1

PASSENGER-CAR EQUIVALENTS FOR TRUCKS AND RVS TO DETERMINE PERCENT TIME-SPENT-FOLLOWING ON TWO-WAY AND DIRECTIONAL SEGMENTS

Vehicle Type	Range of Two-Way Flow Rates (pc/h)	Range of Directional Flow Rates (pc/h)	Type of Terrain	
			Level	Rolling
Trucks, E_T	0–600	0–300	1.1	1.8
	> 600–1,200	> 300–600	1.1	1.5
	> 1,200	> 600	1.0	1.0
RVs, E_R	0–600	0–300	1.0	1.0
	> 600–1,200	> 300–600	1.0	1.0
	> 1,200	> 600	1.0	1.0

	Reduction in Average Travel Speed (km/h)					
	No-Passing Zones (%)					
Two-Way Demand Flow Rate, v_p (pc/h)	0	20	40	60	80	100
0	0.0	0.0	0.0	0.0	0.0	0.0
200	0.0	1.0	2.3	3.8	4.2	5.6
400	0.0	2.7	4.3	5.7	6.3	7.3
600	0.0	2.5	3.8	4.9	5.5	6.2
800	0.0	2.2	3.1	3.9	4.3	4.9
1000	0.0	1.8	2.5	3.2	3.6	4.2
1200	0.0	1.3	2.0	2.6	3.0	3.4
1400	0.0	0.9	1.4	1.9	2.3	2.7
1600	0.0	0.9	1.3	1.7	2.1	2.4
1800	0.0	0.8	1.1	1.6	1.8	2.1
2000	0.0	0.8	1.0	1.4	1.6	1.8
2200	0.0	0.8	1.0	1.4	1.5	1.7
2400	0.0	0.8	1.0	1.3	1.5	1.7
2600	0.0	0.8	1.0	1.3	1.4	1.6
2800	0.0	0.8	1.0	1.2	1.3	1.4
3000	0.0	0.8	0.9	1.1	1.1	1.3
3200	0.0	0.8	0.9	1.0	1.0	1.1

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2079 Jestha

Exam.	Regular		
Level	M.Sc.	Full Marks	60
Programme	MSTrE	Pass Marks	30
Year / Part	I / I	Time	3 hrs.

Subject: - Traffic Engineering

- Candidates are required to give their answers in their own words as far as practicable.
- *Attempt any Five questions.*
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- *Necessary charts and tables attached herewith.*
- *Assume suitable data if necessary.*

1. a) Explaining the objectives of conducting OD survey, mention condition of using each method of OD survey. [6]

   b) The parking survey data collected from a parking lot by license plate method is shown in the table below. Find the average occupancy, average turnover, parking load, parking capacity and efficiency of the parking lot. [6]

Bay	Time			
	4:00~4:15	4:15~4:30	4:30~4:45	4:45~5:00
1	780	910	-	1020
2	2023	2023	2023	-
3	1550	1825	-	1825
4	957	957	4624	8045
5	6081	6081	-	7556
6	-	4345	-	5560
7	-	-	676	676
8	965	965	965	-
9	2560	2560	8910	7852
10	2145	-	5570	5570

2. a) An observer standing at a point along a three-lane roadway records the following details. All vehicles in lane 1 are traveling at 50 kmph, all vehicles in lane 2 are traveling at 70 kmph, and all vehicles in lane 3 are traveling at 90 kmph. There is also a constant spacing of 800m between vehicles. If the spot speed data for all vehicles are collected as they cross observation point, for 30 minutes, what will be the time-mean speed and space mean speed for this traffic stream? [6]

   b) What are the basic information provided in collision and condition diagram? How this information will be used in crash analysis? [6]

3. a) A four phase signal system is to be designed for a major intersection. The flow ratios are: [6]
   Phase A $(v/s)_A = 0.25$
   Phase B $(v/s)_B = 0.25$
   Phase C $(v/s)_C = 0.20$
   Phase D $(v/s)_D = 0.15$
   If the total lost time (L) is 14 seconds/cycle, determine
   i) The shortest cycle length for avoiding oversaturation.
   ii) The cycle length if the desired critical v/c ratio X_c is 0.95.
   iii) The critical v/c ratio X_c if a cycle length of 90 seconds is used.

   b) Explain the importance of sub hourly volume measurement. How driver's behavior is considered in traffic engineering? [3+3]

4. a) Describe the levels of intersection control. What is channelization? Explain the critical factors that affect the capacity of rotary roadway. [2+2+2]

   b) A pretimed four-phase signal has critical lane group flow rates for the first three phases of 200, 187, and 210 veh/h (saturation flow rates are 1800 veh/h/ln for all phases). The lost time is known to be 4 seconds for each phase. If the cycle length is 60 seconds, what is the estimated effective green time of the fourth phase? [6]

5. a) A rural freeway has a 5 percent upgrade 1.2 km long. Expected traffic composition is 10 percent trucks and buses and 10 percent recreational vehicles. The adjustment factor for the character of the traffic stream is expected to be 0.75. Ideal free-flow speed is 120 km/h. Interchanges are about 8 km apart. If the hourly volume is expected to be 1,950 VPH with a peak hour factor of 0.85, how many lanes are needed to provide level of service C? [6]

   b) Derive an expression for Webster's uniform delay for signalized intersection mentioning the assumptions involved. [6]

6. Write short notes on: (Any three) [3×4]
   a) Congestion measurement
   b) Use of queuing analysis in traffic engineering
   c) Use of shockwave phenomena in traffic engineering
   d) Vehicle actuated signal

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Criteria	LOS				
	A	B	C	D	E
FFS = 120 km/h					
Maximum density (pc/km/ln)	7	11	16	22	28
Minimum speed (km/h)	120.0	120.0	114.6	99.6	85.7
Maximum v/c	0.35	0.55	0.77	0.92	1.00
Maximum service flow rate (pc/h/ln)	840	1320	1840	2200	2400
FFS = 110 km/h					
Maximum density (pc/km/ln)	7	11	16	22	28
Minimum speed (km/h)	110.0	110.0	108.5	97.2	83.9
Maximum v/c	0.33	0.51	0.74	0.91	1.00
Maximum service flow rate (pc/h/ln)	770	1210	1740	2135	2350
FFS = 100 km/h					
Maximum density (pc/km/ln)	7	11	16	22	28
Minimum speed (km/h)	100.0	100.0	100.0	93.8	82.1
Maximum v/c	0.30	0.48	0.70	0.90	1.00
Maximum service flow rate (pc/h/ln)	700	1100	1600	2095	2300
FFS = 90 km/h					
Maximum density (pc/km/ln)	7	11	16	22	28
Minimum speed (km/h)	90.0	90.0	90.0	89.1	80.4
Maximum v/c	0.28	0.44	0.64	0.87	1.00
Maximum service flow rate (pc/h/ln)	630	990	1440	1955	2250

Lane Width (m)	Reduction in Free-Flow Speed, f_{LW} (km/h)
3.6	0.0
3.5	1.0
3.4	2.1
3.3	3.1
3.2	5.6
3.1	8.1
3.0	10.6

Right-Shoulder Lateral Clearance (m)	Reduction in Free-Flow Speed, f_{LC} (km/h)			
	Lanes in One Direction			
	2	3	4	≥ 5
≥ 1.8	0.0	0.0	0.0	0.0
1.5	1.0	0.7	0.3	0.2
1.2	1.9	1.3	0.7	0.4
0.9	2.9	1.9	1.0	0.6
0.6	3.9	2.6	1.3	0.8
0.3	4.8	3.2	1.6	1.1
0.0	5.8	3.9	1.9	1.3

Interchanges per Kilometer	Reduction in Free-Flow Speed, f_{ID} (km/h)
≤ 0.3	0.0
0.4	1.1
0.5	2.1
0.6	3.9
0.7	5.0
0.8	6.0
0.9	8.1
1.0	9.2
1.1	10.2
1.2	12.1

Number of Lanes (One Direction)	Reduction in Free-Flow Speed, f_N (km/h)
≥ 5	0.0
4	2.4
3	4.8
2	7.3

Note: For all rural freeway segments, f_E is 0.0.

Upgrade (%)	Length (km)	Percentage of Trucks and Buses								
		2	4	5	6	8	10	15	20	25
< 2	All	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
≥ 2–3	0.0–0.4	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	> 0.4–0.8	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	> 0.8–1.2	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	> 1.2–1.6	2.0	2.0	2.0	2.0	1.5	1.5	1.5	1.5	1.5
	> 1.6–2.4	2.5	2.5	2.5	2.5	2.0	2.0	2.0	2.0	2.0
	> 2.4	3.0	3.0	2.5	2.5	2.0	2.0	2.0	2.0	2.0
> 3–4	0.0–0.4	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	> 0.4–0.8	2.0	2.0	2.0	2.0	2.0	2.0	1.5	1.5	1.5
	> 0.8–1.2	2.5	2.5	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	> 1.2–1.6	3.0	3.0	2.5	2.5	2.5	2.5	2.0	2.0	2.0
	> 1.6–2.4	3.5	3.5	3.0	3.0	3.0	3.0	2.5	2.5	2.5
	> 2.4	4.0	3.5	3.0	3.0	3.0	3.0	2.5	2.5	2.5
> 4–5	0.0–0.4	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	> 0.4–0.8	3.0	2.5	2.5	2.5	2.0	2.0	2.0	2.0	2.0
	> 0.8–1.2	3.5	3.0	3.0	3.0	2.5	2.5	2.5	2.5	2.5
	> 1.2–1.6	4.0	3.5	3.5	3.5	3.0	3.0	3.0	3.0	3.0
	> 1.6	5.0	4.0	4.0	4.0	3.5	3.5	3.0	3.0	3.0
> 5–6	0.0–0.4	2.0	2.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	> 0.4–0.5	4.0	3.0	2.5	2.5	2.0	2.0	2.0	2.0	2.0
	> 0.5–0.8	4.5	4.0	3.5	3.0	2.5	2.5	2.5	2.5	2.5
	> 0.8–1.2	5.0	4.5	4.0	3.5	3.0	3.0	3.0	3.0	3.0
	> 1.2–1.6	5.5	5.0	4.5	4.0	3.0	3.0	3.0	3.0	3.0
	> 1.6	6.0	5.0	5.0	4.5	3.5	3.5	3.5	3.5	3.5

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Examination Control Division
2075 Bhadra

Exam	**Regular/Back**		
Level	**M.Sc.**	**Full marks**	**60**
Program	**Transportation Engineering**	**Pass marks**	**30**
Year/Part	**I/I**	**Time**	**3 hrs.**

Subject: - Traffic Engineering *(CE805-C03)*

- ✓ *Candidates are required to give their answer in their own words as far as practicable*
- ✓ *Attempt **All** questions.*
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1. a) Explaining the objectives of conducting OD survey, mention condition of using each method of OD survey. [6]

   b) On a 2.8km long link of road, it was found that the vehicle demand was 1000, 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. [6]

2. a) A 24 hr. count using a pressure tube at a highway location produces 11250 actuations. A representative sample count to classify vehicles resulted in the data shown here. [8]

No. of axles per vehicle	No. of vehicles observed
2	157
3	55
4	50
5	33
6	8

Based on this sample classification count, how many vehicles were observed during the 24 hr. study. Explain the significance of control and coverage counts.

   b) Explain the general requirements of traffic control devices. [4]

3. a) An analysis of pedestrian needs at a signalized intersection is undertaken. Important parameters related to pedestrian needs and existing vehicular signal timing are given in the table. Are pedestrians safely accommodated by this signal timing? If not, what signal timing should be implemented? [6]

Phase	G(s)	Y(s)	G_p(s)
A	18.0	4.5	30.0
B	60.0	4.0	15.0

   b) 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 or changing either to the 1st or 3rd lanes. These decisions are governed by the utilities of the lanes (U_l) and gaps (U_g). On which lane would the vehicle like to travel probably?
U_l = 3.467-0.0757 * Relative speed – 0.0064 * Frontgap
U_g = 5.567-0.03 * Leadgap – 0.0129 * Laggap [6]

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

4. a) A four-phase traffic signal has critical lane group flow ratios of 0.225, 0.175, 0.200 and 0.150. If the lost time per phase is 5 seconds and a critical intersection v/c of 0.85 is desired, calculate the minimum cycle length and the phase effective green times such that the lane group v/c ratios are equalized. [6]

   b) Describe the working principle and various control parameters of a vehicle actuated controller and its limitations. [6]

5. a) A 1.5 km section of rural freeway has a +3% grade. The DDHV is 2500 veh/hr (weekday) including 20% trucks with a PHF of 0.90. The lanes are 3.6m wide with no lateral obstructions on both sides of the freeway and has an average of 0.25 interchanges per km. Determine the number of lanes required on this grade segment, including the climbing lane for trucks for LOS B. [6]

   b) Explain the shock-wave phenomenon and derive the expression for speed of a shock wave with the help of neat diagrams. [6]

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2074 Chaitra

Exam	**Regular**		
Level	**M.Sc.**	**Full marks**	**60**
Program	**Transportation Engineering**	**Pass marks**	**30**
Year/Part	**I/I**	**Time**	**3 hrs.**

Subject: - Traffic Engineering *(CE828)*

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- ✓ *Attempt **any** **Five** questions.*
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- ✓ *Assume suitable data if necessary.*

1. a) What is the difference between flow, capacity and demand and level of service in the traffic stream? [4]

   b) A 24 hr. count using a pressure tube at a highway location produces 11250 actuations. A representative sample count to classify vehicles resulted in the data shown here. [8]

No. of axles per vehicle	No. of vehicles observed
2	157
3	55
4	50
5	33
6	8

   Based on this sample classification count, how many vehicles were observed during the 24 hr. study. Explain the significance of arrival and departure volumes at intersection.

2. a) A pretimed four-phase signal has critical lane group flow rates for the first three phases of 200, 187, and 210 veh/h (saturation flow rates are 1800 veh/h/ln for all phases). The lost time is known to be 4 seconds for each phase. If the cycle length is 60 seconds, what is the estimated effective green time of the fourth phase? [6]

   b) What are the critical design elements of rotary intersection? How the design of one element affects another, explain with example. [6]

3. a) Recent analysis at an approach to a pretimed-signalized intersection indicate that the volume-to-capacity ratio is 0.8, the saturation flow rate is 1600 veh/h, and the effective green time is 50 seconds. If the uniform delay is 11.25 seconds per vehicle, determine the arrival flow rate (in veh/h) and the cycle length. [6]

   b) Briefly describe the principles involved in the design of at grade intersection. What are the functions of different channelizing islands at grade intersection? [6]

4. a) A Traffic on the eastbound approach of a signalized intersection is travelling at 40 kmph, with a density of 44 veh/km/ln. The duration of the red signal indication for this approach is 30 sec. If the saturation flow is 19500 veh/h/ln with a density of 51 veh/km/ln, and the jam density is 120 veh/km/ln, determine the following:
      (i) The length of the queue at the end of the red phase.
      (ii) The time it takes for the queue to dissipate after the end of the red indication. [6]

   b) Explain the components of queuing system. What information are to be provided on collision diagram? [6]

5. a) A section of 4-lane freeway (2 lanes in each direction with length 3.2 km has a sustained grade of 4% is to be improved to carry design volume of 3000 veh/h consisting of 85% passenger cars, 10% trucks, 2% buses and 3% recreational vehicles. The PHF is 0.95. Determine the additional number of lanes required in each direction if the road is to operate at the level of service of B. The base free flow speed is 112 kmph. There is lateral obstruction 1.5 m from the pavement on the right side of the road and interchange spacing is 1.6 km. [6]

   b) Explain how driver's behavior can be taken into account while designing traffic control devices? [6]

6. Write short notes on: [4*3]

   a) Difference between freeway and multilane highway

   b) Congestion mitigation measures

   c) Actuated traffic signal system

   d) Date for comprehensive parking study

TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2073 Chaitra

Exam	**Regular**		
Level	**M.Sc.**	**Full marks**	**60**
Program	**Transportation**	**Pass marks**	**30**
Year/Part	**I/I**	**Time**	**3 hrs.**

Subject: - Traffic Engineering *(CE823)*

- ✓ *Candidates are required to give their answer in their own words as far as practicable*
- ✓ *Attempt **any Five** questions.*
- ✓ *The figures in the margin indicate Full Marks.*
- ✓ *Necessary charts and tables are attached herewith.*
- ✓ *Assume suitable data if necessary.*

1. a) Derive the fundamental relationship between speed, flow and density of a traffic stream. [6]

   b) Data collected at a parking lot indicate that a total of 300 cars park between 8 a.m. and 6 p.m. 10% of these cars are parked for an average of 2 hr, 20% for an average of 4 hr, and the remaining cars are parked for an average of 8 hr. Determine the space-hours of demand at the lot. If 10% of the parking bays are vacant on average (between 8 a.m. and 6 p.m.) at the parking lot, determine the number of parking bays in the parking lot. Assume an efficiency factor of 0.85 [6]

2. a) The width of approaches for a rotary intersection is 15 m. The entry and exit width at the rotary is 10 m. Table below gives the traffic from the four approaches, traversing the intersection. Determine the capacity of the rotary. [6]

Approach	Left turn	Straight	Right turn
North	400	700	300
South	350	370	420
East	200	450	550
West	350	500	520

   b) Explain the different components of queuing system. [6]

3. a) A four phase signal system is to be designed for a major intersection. The flow ratios are: [6]
   Phase A $(v/s)_A = 0.25$
   Phase B $(v/s)_B = 0.25$
   Phase C $(v/s)_C = 0.20$
   Phase D $(v/s)_D = 0.15$
   If the total lost time (L) is 14 seconds/cycle, determine
   i. The shortest cycle length for avoiding oversaturation.
   ii. The cycle length if the desired critical v/c ratio X_c is 0.95.
   iii. The critical v/c ratio X_c if a cycle length of 90 seconds is used.

   b) What is the use of origin destination survey in transport planning? Explain the different conditions of applying different methods of O-D survey. [6]

4. a) Explain why drivers behavior should be taken into account while designing traffic control devices? [6]

   b) A study at an intersection approach found that the approach speed was 50 kmph. Given that short loop detector was located 25 m upstream of the stop line, calculate (i) appropriate unit extension and (ii) the required minimum green interval. [6]

5. a) Design the freeway section with the following conditions: [8]
Volume: 5000 vph
LOS: C
PHF=0.90
Free Flow Speed 112 kmph
Lane width = 3.6 m
Percent Truck (P_T) = 10%
No lateral clearance and rolling terrain.
Interchange spacing = 4 km
Determine the minimum number of lanes.

b) Explain the general requirements of traffic control devices. [4]

6. Write short notes on: [4*3]

a) Data to be collected in comprehensive parking survey

b) Arrival vs Departure volume

c) Congestion measurement

TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2072 Chaitra

Exam	**Regular**		
Level	**M.Sc.**	**Full marks**	**60**
Program	**Transportation**	**Pass marks**	**30**
Year/Part	**I/I**	**Time**	**3 hrs.**

Subject: - Traffic Engineering

- ✓ *Candidates are required to give their answer in their own words as far as practicable*
- ✓ *Attempt **any Five** questions.*
- ✓ *The figures in the margin indicate Full Marks.*
- ✓ *Necessary charts and tables are attached herewith.*
- ✓ *Assume suitable data if necessary.*

1. a) Describe how color, shape and legend are used to convey and reinforce messages of traffic signs. [4]

   b) A traffic engineer needs to determine the AADT on a rural road that has the volume distribution characteristics as shown in the table. The data collected shown below on a Tuesday during month of Bhadra. Determine the AADT of the road. [8]

7:00 – 8:00 am	400
8:00 – 9:00 am	535
9:00 – 10:00 am	650
10:00 – 11:00 am	710
11:00 am – 12:00 noon	650

Hourly Volume Count Date				**Daily Volume Count Data**		**Monthly Volume Count Data**	
Hour	**Volume**	**Hour**	**Volume**	**Day of Week**	**Volume**	**Month**	**ADT**
6-7 am	294	6-7 pm	743	Sunday	7895	Baisakh	1350
7-8 am	426	7-8 pm	706	Monday	10714	Jestha	1200
8-9 am	560	8-9 pm	606	Tuesday	9722	Aashadh	1450
9-10 am	657	9-10 pm	489	Wednesday	11413	Shrawan	1600
10-11 am	722	10-11 pm	396	Thursday	10714	Bhadra	1700
11-12 pm	667	11-12 am	360	Friday	13125	Aswin	2500
12-1 pm	660	12-1 am	241	Saturday	11539	Kartik	4100
1-2 pm	739	1-2 am	150			Mangsir	4550
2-3 pm	832	2-3 am	100			Poush	3750
3-4 pm	836	3-4 am	90			Magh	2500
4-5 pm	961	4-5 am	86			Falgun	2000
5-6 pm	892	5-6 am	137				

2. a) A signalized intersection approach has three lanes with no exclusive turning lanes. The approach has 40 second green time. Cycle length is 75 seconds. The yellow and all red interval for the subject phase is 14 seconds. If the start up lost time is 2.3 seconds and the clearance lost time is 1.1 s/phase, saturation headway is 2.48 seconds/veh, what is the capacity of the intersection approach? [6]

   b) At a signalized intersection, one lane is observed to discharge 20 through vehicles in the same time as the right lane discharges 10 through vehicles and 5 right turning vehicles, what is the right turn adjustment factor, f_{RT} ? What variables affect the observed value of through vehicle equivalent E_{RT} for right turn vehicles? [6]

3. a) The width of approaches for a rotary intersection is 15 m. The entry and exit width at the rotary is 10 m. Table below gives the traffic from the four approaches traversing the intersection. Find the capacity of the rotary. [8]

Approach	LT	TH	RT
North	450	625	370
South	549	358	475
East	412	465	493
West	450	413	483

b) What are the ill effects of congestion? Discuss some measures of congestion management in an urban area. [4]

4. a) A traffic stream with a mean space mean speed of 30 kmph on a single lane of a two-lane street is brought to a halt when approaching a signalized intersection for a duration of 30 seconds. The capacity of this lane is 1800 veh/hr and the jam density is 180 veh/km. Determine the velocity of the stopping shockwave if the red phase lasts for 30 sec. [6]

b) At a parking lot, vehicles arrive according to Poisson process and parking fees are collected at an exponentially distributed rate at a single station. The mean processing rate if 5 veh/min and the rate of arrival is 4 veh/min. Determine the average length of queue, the average time spent in the system and the average waiting time in the queue. [6]

5. a) A four-lane multilane highway section with a full median carries a peak-hour volume of 2600 veh/hr in the heaviest direction. There are 12% trucks and 2% RVs in the traffic stream. Motorists are primarily regular users of the facility. The section under study is on a 3% sustained grade, 1.5 km in length. The PHF is 0.88. Field studies have been conducted to determine that free-flow speed of the facility is 90 kmph. At what level of service will this facility operate during the peak hour? [6]

b) Briefly describe the tasks to be included in a comprehensive parking study indicating how you would perform each task and the way you would present the data collected. [6]

6. Write short notes on: [4*3]

a) Read End Collision at intersections causes and data required

b) O-D Survey

c) Actuated traffic signal system

d) Speed and Delay analysis

TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2071 Chaitra

Exam	**Regular**		
Level	**M.Sc.**	**Full marks**	**60**
Program	**Transportation**	**Pass marks**	**30**
Year/Part	**I/I**	**Time**	**3 hrs.**

Subject: - Traffic Engineering *(CE823)*

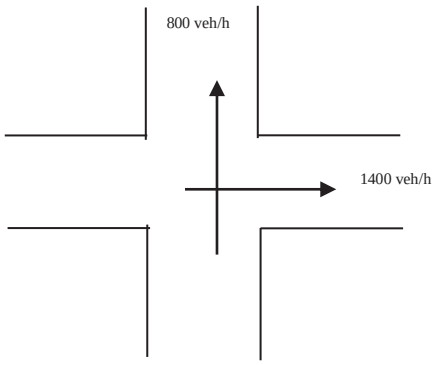
- ✓ *Candidates are required to give their answer in their own words as far as practicable*
- ✓ *Attempt **any Five** questions.*
- ✓ *The figures in the margin indicate Full Marks.*
- ✓ *Necessary charts and tables are attached herewith.*
- ✓ *Assume suitable data if necessary.*

1. a) Briefly describe the different principles involved in the design of at grade intersection. [6]

   b) A parking study has found that average parking duration in the city center is 35 minutes and the following spaces are available within 14 hours study period (6:00 am to 8:00 pm) with a 90% efficiency factor. How many vehicles may be parked in the study area in one 14 hour day? [6]

No. of spaces	Time available
100	6:00 am to 8:00 pm
150	12:00 noon to 8:00 pm
200	6:00 am to 12:00 noon
300	8:00 am to 6:00 pm

2. a) For the intersection shown below, find the followings
   i) Absolute minimum cycle length that could be used.
   ii) Cycle length that would be required to provide for a ratio of 0.9 during the worst 15 minutes of the hour if PHF is 0.92. [6]



h = 2.05 s/veh
t_L = 4.3 s/phase
2-phase signal
C = 60 s
Only critical vols. shown

   b) Peak hour volumes at two locations were counted and found to be equal. PHF's were 0.85 at the first location and 0.60 at the second location. Describe the difference between the locations if t = 5 min. [6]

3. a) A study at an intersection approach found that the approach speed was 50 kmph. Given that short loop detector was located 25 m upstream of the stop line, calculate (a) appropriate unit extension and (b) the required minimum green interval. [6]
   b) Explain capacity of rotary intersection along with the factors affecting it. [6]

4. a) Under what conditions would you recommend the use of (a) yield sign (b) stop sign and (c) multiway stop sign at urban intersections. [6]

   b) A loop detector having a length of 3.6 m was observed to have 6 vehicles cross over it in a period of 148 seconds for the following durations: 0.44, 0.48, 0.50, 0.41, 0.49 and 0.55. Estimate the average values of flow, density and speed. The corresponding length of vehicles were 5.4, 6.3, 6.0, 6.9, 5.1 and 5.7 m. [6]

5. a) An urban freeway is to be designed on the basis of the following information. [6]
   Design year AADT = 8200 veh/day
   Peak hour fraction (K) = 10%
   Peak directional proportion (D) = 0.55
   10% buses, 5% recreational vehicles, 10% trucks, PHF = 0.90, level terrain, no lateral obstructions, design standard LOS = D. Determine the number of lanes needed if estimated FFS = 100 kmph.

   b) Why queuing analysis is important in traffic engineering? Also briefly explain its component. [6]

6. Write short notes on: [4*3]

   a) Critical parameters of road users

   b) Parameters for congestion measurement

   c) Control counts and coverage counts

   d) Shockwave

TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2070 Chaitra

Exam	**Regular**		
Level	**M.Sc.**	**Full marks**	**60**
Program	**Transportation**	**Pass marks**	**30**
Year/Part	**I/I**	**Time**	**3 hrs.**

Subject: - Traffic Engineering *(CE823)*

- ✓ *Candidates are required to give their answer in their own words as far as practicable*
- ✓ *Attempt **any Five** questions.*
- ✓ *The figures in the margin indicate Full Marks.*
- ✓ *Necessary charts and tables are attached herewith.*
- ✓ *Assume suitable data if necessary.*

1. a) Describe how the journey speed of the traffic stream may be measured. [6]

   b) Data collected at a parking lot indicate that a total of 300 cars park between 8 a.m. and 6 p.m. 10% of these cars are parked for an average of 2 hr, 30% for an average of 4 hr, and the remaining cars are parked for an average of 10 hr. Determine the space-hours of demand at the lot. If 10% of the parking bays are vacant on average (between 8 a.m. and 6 p.m.) at the parking lot, determine the number of parking bays in the parking lot. Assume an efficiency factor of 0.85. [6]

2. a) On a two lane carriageway roadworks restrict the width of both traffic lanes forming a bottleneck to traffic flow. The maximum flow per lane on the unobstructed carriageway is 2500 vph whilst on the section under repair the maximum flow per lane is 2000 vph. When stationary, vehicles are spaced at average distance headways of 8 m. Assume linear speed density relationship. When the traffic flow approaching the roadworks is 4500 vph, calculate [8]
   (i) The speed of traffic stream a considerable distance in advance of the bottleneck.
   (ii) The speed of the traffic stream immediately before the commencement of the bottleneck.
   (iii) The speed of the shockwave formed by the bottleneck.

   b) Describe the two sources of delay experienced by vehicles at highway intersections. [4]

3. a) 10 vehicles wait for a green light. The 2nd vehicle is a truck, the 5th is a bus and there are three right turns. Calculate time required for the 10 vehicles to enter the intersection if each right turn vehicle consumes 1.3 seconds more time and heavy vehicle consumes 1.5 times more time than that of car. [6]

Car in line (N)	1	2	3	4	5	6	7	8	9	10
Green time consumed (sec)	3.8	3.1	2.7	2.4	2.2	2.1	2.1	2.1	2.1	2.1

   b) Explain the use of time space diagram with example. [6]

4. a) Explain the three critical parameter of vehicle actuated signal control system. [6]

   b) The minimum cycle length for an intersection is determined to be 95 seconds. The critical lane group flow ratios were calculated as 0.235, 0.250, 0.170 and 0.125 for phase 1-4 respectively. What X_c was used in the determination of this cycle length, assuming a lot of 5 seconds per phase? [6]

5. a) An urban freeway presently has three 3.6 m lanes on a 3 percent upgrade 2.8 km long. The traffic includes 8 percent trucks and buses (Recreational vehicles are negligible). There are no lateral obstructions. Interchanges are about 1.3 km apart. The peak hour factor is 0.90. Ideal free-flow speed is 110 km/h. [8]
   i) What maximum hourly volume can currently be accommodated by the upgrade (at capacity)?
   ii) How much this could be increased by widening and remarking the existing roadway to provide four 3-m lanes up the grade?

   b) Explain the general requirements of traffic control devices. [4]

6. Write short notes on: [4*3]

a) Accident analysis process
b) Use of O-D survey
c) Congestion measurement
d) Driver’s behavior in traffic engineering

TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2069 Chaitra

Exam	**Regular**		
Level	**M.Sc.**	**Full marks**	**60**
Program	**Transportation Planning**	**Pass marks**	**30**
Year/Part	**I/I**	**Time**	**3 hrs.**

Subject: - Traffic Engineering

- ✓ *Candidates are required to give their answer in their own words as far as practicable*
- ✓ *Attempt **any Five** questions.*
- ✓ *The figures in the margin indicate Full Marks.*
- ✓ *Necessary charts and tables are attached herewith.*
- ✓ *Assume suitable data if necessary.*

1. a) Describe screen line counts, cordon counts, intersection counts and control counts with their specific uses? [6]

   b) A freeway has a flow-density relationship approximated by

   $q = 80k$ for $0 \leq k \leq 30$
   $q = 3200-26.67k$ for $30 \leq k \leq 120$

   where k is in vehicles/lane/kilometer. Flow on a particular day is approximately 1800 veh/lane/hr. At 11:00 a.m. an incident occurs that reduces capacity to 1500 veh/lane/h. After 40 min, the incident is cleared, which increases capacity to its normal value of 2,400 veh/lane/h. What are the speeds of the forming and clearing waves that result? [6]

2. a) A rural freeway has a 5 percent upgrade 1.2 km long. Expected traffic composition is 10 percent trucks and buses and 10 percent recreational vehicles. The adjustment factor for the character of the traffic stream is expected to be 0.75. Ideal free-flow speed is 120 km/h. Interchanges are about 8 km apart. If the hourly volume is expected to be 1,950 VPH with a peak hour factor of 0.85, how many lanes are needed to provide level of service C? [6]

   b) Explain the different types of islands used in channelizing at grade intersections with their function. [6]

3. a) For a two-phase, two intersecting streets a and b wih one lane at each approach, the total movement volumes (for critical approaches a and b) V_a and V_b and the departure headways h_a and h_b, the following conditions are given:

   $Y_a = Y_b = 4.5$ sec. (yellow time)
   No all red time
   $h_a = 2.1$ sec
   $h_b = 1.9$ sec
   $V_a = 500$ vph
   $V_b = 450$ vph
   PHF = 0.85
   You need to design the timing plan. [6]

   b) Briefly describe the tasks you would include in a comprehensive parking study in your locality indicating how you would perform each task and the way you would present the collected data. [6]

4. a) Explain the different components of queuing system. [4]

b) A four phase signal system is to be designed for a major intersection. The flow ratios are:
Phase A $(v/s)_A = 0.25$
Phase B $(v/s)_B = 0.25$
Phase C $(v/s)_C = 0.20$
Phase D $(v/s)_D = 0.15$
If the total lost time (L) is 14 seconds/cycle, determine
   i. The shortest cycle length for avoiding oversaturation.
   ii. The cycle length if the desired critical v/c ratio X_c is 0.95
   iii. The critical v/c ratio X_c if a cycle length of 90 seconds is used. [8]

5. a) How are travel time and delay studies used? Describe one method for collecting travel time and delay data at a section of a highway. Explain how to obtain the following information from the data collected: (a) travel time, (b) operational delay, (c) stopped time delay, (d) fixed delay, and (e) travel time delay. [6]

b) A test of driver's perception reaction time is being conducted on a special testing track with wet pavement and a driving speed of 90 kmph. When the driver is sober, a stop can be made just in time to avoid hitting an object that is first visible 160 m ahead. After a few drinks under the exact same conditions, the driver fails to stop in time and strikes the object at a speed of 50 kmph. How much slow is the driver after drinking? (Assume rate of deceleration after brake applications as 3.41 m/sec^2) [6]

6. Write short notes on: [4*3]

a) Input parameters for LOS analysis of signalized intersection

b) Accident statistics

c) Traffic regulations

TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2068 Chaitra

Exam	**Regular**		
Level	**M.Sc.**	**Full marks**	**60**
Program	**Transportation Planning**	**Pass marks**	**30**
Year/Part	**I/I**	**Time**	**3 hrs.**

Subject: - Traffic Engineering

- ✓ *Candidates are required to give their answer in their own words as far as practicable*
- ✓ *Attempt **any Five** questions.*
- ✓ *The figures in the margin indicate Full Marks.*
- ✓ *Necessary charts and tables are attached herewith.*
- ✓ *Assume suitable data if necessary.*

1. a) Under what conditions the time mean speed and space mean speed will be equal? Prove it mathematically. [6]

   b) A parking facility attached to a business mall has accumulation factors (=accumulation/total no. of parkers) as given in the table below. There are 1625 executives of which 80% use the parking facility (car occupancy = 1.3). Work out the cumulative arrivals and departures on a typical day. Assume 20% executives are short term parkers (not more than 2 hours). [6]

Period	Accumulation factor	
	Long term	Short term
7-8 AM	0.75	-
8-9	1	0.05
9-10	1	0.125
10-11	1	0.175
11-12 PM	1	0.200
12-1 PM	1	0.225
1-2	1	0.25
2-3	1	0.275
3-4	1	0.25
4-5	0.25	0.200
5-6	0	0.175
6-7	-	0.125
7-8	-	0

2. a) Design the freeway section with the following conditions: [8]

   Volume: 3500 vph (one direction)
   LOS: C
   PHF = 0.85
   Free Flow Speed: 112 kmph
   Lane width = 3.5 m
   Percent Truck (P_T) = 10%
   Percent Bus (P_a) = 0
   Percent Recreational Vehicle (P_R) = 5%
   Adequate lateral clearance and type of terrain: level
   (i) Determine the minimum number of lanes
   (ii) If one more lane is added; determine what the level of service will be.

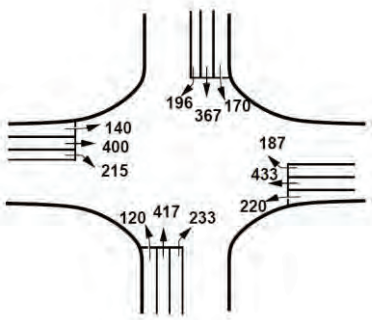
   b) Explain the different parameters for measuring congestion and suggest your remedial measures to curb the growing traffic congestion problem of Kathmandu. [4]

3. a) A signalized intersection approach has a lane group with the following signal timing. [6]
Cycle length = 80 sec
Green time = 30 sec
Yellow time = 4 sec
All red time = 2 sec
According to field data collection and analysis, it is found that the startup lost time and yellow lost time for this lane group are 2 seconds and 1 second, respectively. If the lane group saturation flow rate under prevailing conditions is 3500 vphgpl, what is the capacity for this lane group?

b) What is use of origin destination survey in transport planning? Explain the different conditions of applying different methods of O-D survey. [6]

4. a) Explain the detail how different factors are considered in the design of weaving section at a rotary intersection. [4]

b) The traffic flow at an intersection is shown as below, the figures indicating the flow volume in pcu. The lost time per phase is 2.4 seconds with saturation headway of 2.2 seconds. Amber time to be provided is 3 seconds per phase and the volume to capacity ratio is 0.9. Find the four phase signal timing with all red pedestrian crossing interval and performance measure of the intersection. (Note: Assume left turn permitted) [8]



5. a) The driver of a vehicle is following another vehicle in front of her in a two lane highway at night. She keeps a clearance of one car length for every 16 kmph of speed while she follows the lead car. However, while going downhill at 80 kmph, the lead car crashes into the rear of an unlighted abandoned truck. At what speed will her car hit the wreckage? Assume a perception reaction time of 2 seconds, a deceleration rate of 3.41 m/s^2, the length of car of 6 m and road grade as 5%. [6]

b) Discussing various causes of accidents, elaborate the procedures for detailed accident analysis. [6]

6. Write short notes on: [4*3]

a) Shockwave

b) Traffic flow models

c) Right turn equivalency factor

d) Arrival vs Departure volume

Institute of Engineering
Central Campus
Department of Civil Engineering
M. Sc. in Transportation Engineering I/I

Subject: Traffic Engineering (Internal Assessment)
Full Marks: 60
Pass marks: 30
Time: 1 hr.
Attempt all

1. A traffic engineer needs to determine the AADT on a rural road that has the volume distribution characteristics as shown in the table. The data collected shown below on a Tuesday during month of May. Determine the AADT of the road

7:00 – 8:00 am	400
8:00 – 9:00 am	535
9:00 – 10:00 am	650
10:00 – 11:00 am	710
11:00 – 12:00 noon	650

Hour	Volume
6:00–7:00 a.m.	294
7:00–8:00 a.m.	426
8:00–9:00 a.m.	560
9:00–10:00 a.m.	657
10:00–11:00 a.m.	722
11:00–12:00 p.m.	667
12:00–1:00 p.m.	660
1:00–2:00 p.m.	739
2:00–3:00 p.m.	832
3:00–4:00 p.m.	836
4:00–5:00 p.m.	961
5:00–6:00 p.m.	892

Hour	Volume
6:00–7:00 p.m.	743
7:00–8:00 p.m.	706
8:00–9:00 p.m.	606
9:00–10:00 p.m.	489
10:00–11:00 p.m.	396
11:00–12:00 a.m.	360
12:00–1:00 a.m.	241
1:00–2:00 a.m.	150
2:00–3:00 a.m.	100
3:00–4:00 a.m.	90
4:00–5:00 a.m.	86
5:00–6:00 a.m.	137

Day of Week	Volume
Sunday	7895
Monday	10,714
Tuesday	9722
Wednesday	11,413
Thursday	10,714
Friday	13,125
Saturday	11,539

Month	ADT
January	1350
February	1200
March	1450
April	1600
May	1700
June	2500
July	4100
August	4550
September	3750
October	2500
November	2000
December	1750

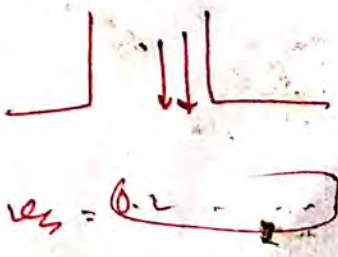
2. A parking study has found that the average parking duration in a shopping mall is 35 minutes and that the following parking spaces are available within the 14-hour study period (6 am to 8 pm) with 90% efficiency. How many vehicles may be parked in the study area in one 14-hour day?

Number of Spaces	Time Available
100	6:00 AM–8:00 PM
150	12:00 noon–8:00 PM
200	6:00 AM–12:00 noon
300	8:00 AM–6:00 PM

3. Explain why and how drivers' behavior should be taken into account while designing traffic control devices?
4. An intersection approach has three lanes with permitted right turns and 6% right turning vehicles with through vehicle equivalence factor of 5.0 veh/right turn. The saturation flow rate for through vehicles under prevailing condition is 1700 veh/h/lane. Find (a) right turn adjustment factor (b) Saturation flow rate and saturation headway (c) if effective green time is 45 seconds in 75 seconds cycle time, capacity of the approach.

5. Consider the traffic volumes and saturation flow rates for the different movement as shown in table below. Design the signal timing with yellow time = 3 seconds, lost time = 2 secs, PHF=0.95 and V/C = 0.9).

Movement	Approach	Direction	Volume, pcu/hr	Saturation flow rate, pcu/hr
1	North	Through+ Right	930	1800
2	South		700	
3	East		650	2000
4	West		420	

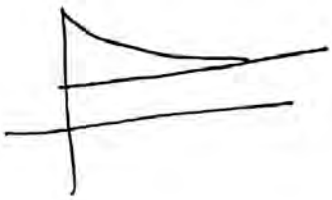


Internal Assessment : *Traffic Engineering*

- *The figures in the margin indicate Full marks.*
- *Assume missing data if necessary. Necessary charts and tables attached.*
- *Attempt any five questions.*

a) A line of vehicles at a signalized intersection begins to move with the initiation of a green signal. The following values represent the headway between vehicles as they cross the intersection line. Compute (1) saturation headway, (2) saturation flow rate, and (3) start up lost time. [6]

Vehicle in Queue	Headway (sec.)
1	2.5
2	2.4
3	2.2
4	2.0
5	1.9
6	1.9
7	1.9
8	1.9
9	1.9



b) The driver of a vehicle is following another vehicle in front of her in a two lane highway at night. She keeps a clearance of one car length for every 16 kmph of speed while she follows the lead car. However, while going downhill at 80 kmph, the lead car crashes into the rear of an unlighted abandoned truck. At what speed will her car hit the wreckage? Assume a perception reaction time of 2 seconds, a deceleration rate of 3.41 m/s^2, the length of car of 6 m and road grade as 5%. [6]

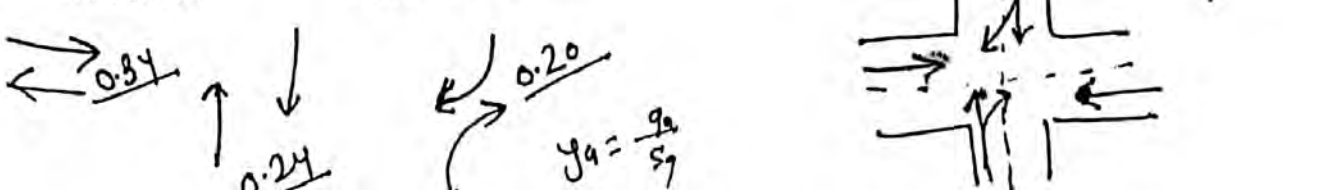
a) The width of approaches for a rotary intersection is 15 m. The entry and exit width at the rotary is 10 m. Table below gives the traffic from the four approaches, traversing the intersection. Determine the capacity of the rotary. [6]

Approach	Left turn	Straight	Right turn
North	400	700	300
South	350	370	420
East	200	450	550
West	350	500	520

b) Explain the different components of queuing system. [6]

a) Flow rates are given below for each lane group of an intersection. Determine the minimum cycle length and phase splits using the Webster method. Loss time is equal to the sum of the yellow intervals which are 3 seconds each. The minimum green time for each phase is 15s. Prepare a traditional signal timing plan with the cycle given as a multiplier of 5s. [6]

Lane group:	NBRT	SBRT	NB	SB	EB	WB
Flow ratio:	0.18	0.20	0.22	0.24	0.32	0.34



b) Explain the importance of sub hourly volume measurement. How it is considered in the traffic engineering analysis? [6]

4 a) Explain why drivers behavior should be taken into account while designing traffic control devices? [6]

b) An intersection approach at an isolated pretimed signal with a cycle length of 80 s has a saturation flow rate of 3000 veh/hr. The length of the green is 24 s. The v/c ratio is 0.90. What is the control delay measured over 15 min interval? [6]

5 a) Design the freeway section with the following conditions: [8]

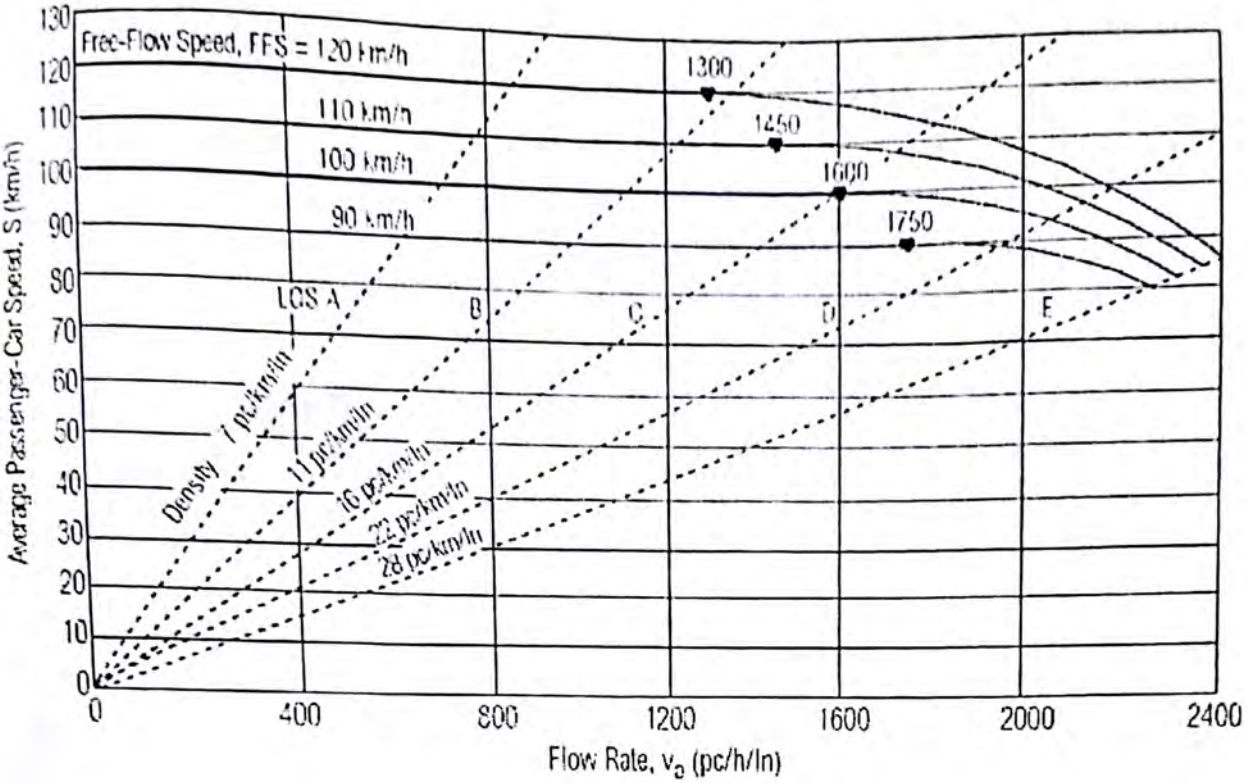
Volume: 5000 vph
LOS: C
PHF=0.90
Free flow speed 112 kmph
Lane width = 3.6 m
Percent Truck (P_T) = 10%
No lateral ~~clearance~~ and rolling terrain.
Interchange spacing = 4 km
Determine the minimum number of lanes.

b) Explain the general requirements of traffic control devices. [4]

Write short notes on: [4x3]

a) Data to be collected in comprehensive parking survey
b) Arrival vs Departure volume
c) Congestion measurement

Criteria	LOS A	B	C	D	E
FFS = 120 km/h					
Maximum density (pc/km/ln)	7	11	16	22	28
Minimum speed (km/h)	120.0	120.0	114.6	99.6	85.7
Maximum v/c	0.35	0.55	0.77	0.92	1.00
Maximum service flow rate (pc/h/ln)	840	1320	1840	2200	2400
FFS = 110 km/h					
Maximum density (pc/km/ln)	7	11	16	22	28
Minimum speed (km/h)	110.0	110.0	108.5	97.2	83.9
Maximum v/c	0.33	0.51	0.74	0.91	1.00
Maximum service flow rate (pc/h/ln)	770	1210	1740	2135	2350
FFS = 100 km/h					
Maximum density (pc/km/ln)	7	11	16	22	28
Minimum speed (km/h)	100.0	100.0	100.0	93.8	82.1
Maximum v/c	0.30	0.48	0.70	0.90	1.00
Maximum service flow rate (pc/h/ln)	700	1100	1600	2065	2300
FFS = 90 km/h					
Maximum density (pc/km/ln)	7	11	16	22	28
Minimum speed (km/h)	90.0	90.0	90.0	89.1	80.4
Maximum v/c	0.28	0.44	0.64	0.87	1.00
Maximum service flow rate (pc/h/ln)	630	990	1440	1955	2250



Lane Width (m)	Reduction in Free-Flow Speed, f_{LW} (km/h)
3.6	0.0
3.5	1.0
3.4	2.1
3.3	3.1
3.2	5.6
3.1	8.1
3.0	10.6

	Reduction in Free-Flow Speed, f_{LC} (km/h)			
	Lanes in One Direction			
Right-Shoulder Lateral Clearance (m)	2	3	4	≥ 5
≥ 1.8	0.0	0.0	0.0	0.0
1.5	1.0	0.7	0.3	0.2
1.2	1.9	1.3	0.7	0.4
0.9	2.9	1.9	1.0	0.6
0.6	3.9	2.6	1.3	0.8
0.3	4.8	3.2	1.6	1.1
0.0	5.8	3.9	1.9	1.3

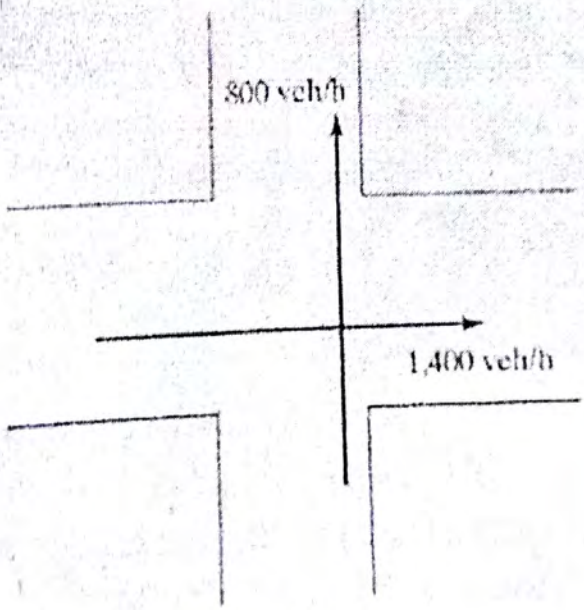
Central Campus
Department of Civil Engineering
M. Sc. in Transportation Engineering I/I

Subject: Traffic Engineering (Internal Assessment)
Full Marks: 60 Pass marks: 30 Time: 1 hr.
Attempt all

1. At the start of 24 km long highway, 100 vehicles were observed passing within 6 min time period with a speed of 20 kmph. Calculate flow, time headway, distance headway, density and the time required to cross the road for the first vehicle.

2. Describe the following types of traffic counts and when they are used.
   (a) Screen line counts
   (b) Cordon counts
   (c) Intersection counts
   (d) Control counts

3. What is the maximum sum of critical-lane volumes that may be served by an intersection having three phases, a cycle length of 100 s, a saturation headway of 2.35 s/veh, and a total lost time per phase of 4.3 seconds? Also find the appropriate number of lanes for each lane group needed for the intersection shown in figure. Assume that all volumes shown have been converted to compatible "through-car equivalent" values for the conditions shown. Assume that critical volumes reverse in the other daily peak hour.



h = 2.05 s/veh
t_L = 4.3 s/phase
2-phase signal
C = 60 s
Only critical vols. shown
All vols. in tvu's