Course Title:  Transportation Engineering I:
Transport and Traffic Design

Course Code: CE 351

Full Marks: 300

Time:  3:00 hours

**THE FIGURES IN THE MARGIN INDICATE FULL MARKS.**
Assume reasonable values for any missing data.
**There are EIGHT questions. Answer any SIX questions.**

1. (a) Explain the main problems associated with the development of road infrastructure and plausible causes of premature failure of pavement in Bangladesh. (25)
   (b) Briefly mention the main weaknesses of Dhaka City in particular relation to transportation system. (25)

2. (a) Write down the objectives and methods of carrying out traffic speed and delay studies? Differentiate between Space-mean-speed and Time-mean-speed. (30)
   (b) The following travel times were observed for 5 vehicles traversing a 2 km segment of highway:

   | Vehicle | Time (min) |
   |---------|-----------|
   | 1 | 1.8 |
   | 2 | 1.3 |
   | 3 | 1.9 |
   | 4 | 1.7 |
   | 5 | 2.1 |

   Calculate the space and time-mean-speeds of the vehicles (8)

   (c) Spot speed data were collected at a section of highway during an improvement work. The speed characteristics are given below. Determine whether there was any significant difference between the average speed at the 95% confidence level. (12)

   $U_1 = 35.2$ Mph      $U_2 = 47.4$ mph
   $S_1 = 5.4$ Mph       $S_2 = 8.9$ mph
   $n_1 = 385$           $n_2 = 350$

3. (a) Differentiate between 'Non-recurrent congestion' & 'Recurrent congestion' and 'Fixed delay' & 'Operation delay'. (10)
   (b) Following data were collected while conducting spot speed studies at certain stretch of a road within the urban area. Determine: (25)
   - average speed, modal speed and pace of the traffic stream.
   - upper and lower values of speed limits for regulation
   - design speed for checking the geometric design

   | Speed Range (kmph) | No. of vehicle observed (f) |
   |--------------------|----------------------------|
   | 0 – 10 | 10 |
   | 10 – 20 | 40 |
   | 20 – 30 | 90 |
   | 30 – 40 | 120 |
   | 40 – 50 | 80 |
   | 50 – 60 | 60 |
   | 60 – 70 | 20 |
   | Total | 420 |

   (c) Differentiate between traffic signs and markings. Briefly discuss about the new trend of roadway signs. State the importance of retro-reflective marking and variable message signs (VMS). (15)

4.(a) Define design parking vehicle. List the locations where parking should be prohibited. Write down the relative advantages and disadvantages of parallel and angled parking. What steps should be undertaken for systematic development of parking facilities? (20)

(b) Why terminal is essential for a city and mention its proper location? Write down the general requirements of a terminal. Define: Terminal, Depot and Workshop. (15)

(c) State the primary objectives of providing street lighting. Design a street lighting system for the following data and draw the layout. Relevant tables and figures are given at the end of the script. (15)

| | |
|---|---|
| Road | = Urban Secondary |
| Pavement width | = 70 ft |
| Surface reflectance | = 20 % |
| Night time flow | = 1100 vph in both direction |
| Source of light | = Sodium |
| Mounting height | = 30 ft |
| Maintenance factor | = 0.8 |

5 (a) List the benefits of traffic signal. Write down the functional classification of traffic signs and give two examples for each. What type of traffic signs is needed for priority typed intersections? (15)

(b) State the general requirements of traffic control devices. Write down the color and pattern convention of road markings. Mention the problems associated with traffic signals in Bangladesh. (15)

(c) Design a two-phase traffic signal for an isolated intersection. The following data are given: (20)

| | |
|---|---|
| Amber period | = 3 sec; Red & Amber period = 2 sec |
| Inter-green period | = 6 sec for N-S phase and 7 sec for E-W phase |
| Initial and final lost times | = 3 sec for N-S phase and 2 sec for E-W phase |

| Approach | North | South | East | West |
|---|---|---|---|---|
| Arrival Flow (pcu/hr) | 400 | 450 | 560 | 458 |
| Saturation flow (pcu/hr) | 1800 | 1780 | 1850 | 1780 |

Draw phase diagram and cycle time bar diagram.

(25)

6. (a) State the objectives of geometric design of highway? Discuss the factors which govern highway alignment. Briefly describe the traffic elements that influence highway design.

(b) Draw a typical highway cross-section and show different cross-sectional elements. (15)

(c) An existing vertical curve on a highway joins +3.0 % grade with a -2.0 % grade. If the length of the curve is 250 ft, what is the maximum safe speed on this curve? Assume f = 0.4 and perception-reaction time is 2.5 sec. Also assume S>L. (10)

7. (a) Define DHV, Directional Distribution and Design Designation. Explain why the transition (spiral) curves are used in horizontal alignment. (15)

(b) What are the principal design criteria for highway? Discuss stopping sight distance (SSD) and passing sight distance (PSD). (15)

(c) Two roads are connected by a horizontal circular curve on level ground. Inside the circular curve there exists an obstruction which may reduce the availability of sight distance. Given the following data, calculate the stopping and passing sight distances required and sight distance available on the circular curve. Also provide your comments on the geometric design of the roadway. (20)

*Data Given:*
   Distance from the center of the road to the edge of the obstruction, c = 120 ft
   Radius of curvature along CL of inside lane, r = 750 ft
   Design speed of the road, u    = 50 mph
   Avg. speed of passing vehicle   = 50 mph
   Avg. speed of passed vehicle   = 40 mph

*Assume:*
   Perception & brake-reaction time, t   = 2.5 sec
   Co-efficient of friction, f      = 0.3
   Avg. acceleration rate, a      = 1.43 mph/sec
   Time for preliminary delay, $t_1$    = 4 sec
   Avg. time while passing vehicle occupies the opposite lane, $t_2$ = 10 sec
   On the circular curve, the sight distance is given by, $S = 200/D * \cos^{-1}[(r - c)/r]$ ft

8 (a) What does it mean by "Level of Service (LOS)"? Name the measures of effectiveness, which qualitatively define "Level of Service (LOS)". (10)

(b) Enumerate the main purposes of roadway furniture? List different types of "Guardrails". Differentiate between "Curbs" and "Gutters". (15)

(c) List different types of horizontal and vertical curves. Mention different ways of attaining super-elevation. Briefly explain the purposes of proving 'curve widening' and 'climbing lane' in rural highway? (15)

(d) A horizontal curve having a radius of 800 ft forms part of a two lane highway that has a posted speed limit of 50 mph. If the highway has 0 % slope at this section, determine the minimum distance a large billboard can be placed from the centerline of the inside lane of the curve, without reducing the required SSD. Assume perception reaction time of 2.5 sec and f = 0.32. (10)

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## TABLES & FIGURES for Question 4 (c)

TABLE 1  RECOMMENDED AVERAGE ILLUMINATION (LUMENS/FT$^2$)

| Pedestrian traffic[1] | Vehicular traffic[2] (vph) | | | |
|---|---|---|---|---|
| | Very light (<150 vph) | Light (150 – 500 vph) | Medium (500 – 1,200 vph) | Heavy (>1,200 vph) |
| Heavy | - | 0.8 | 1.0 | 1.2 |
| Medium | - | 0.6 | 0.8 | 1.0 |
| Light | 0.2 | 0.4 | 0.6 | 0.8 |

Notes: (1) Heavy: As on main business street
     Medium: As on secondary business streets
     Light: As on local streets
  (2) Night hour flow in both directions

TABLE 2  ADJUSTMENT FACTORS FOR RECOMMENDED AVERAGE ILLUMINATION VALUES

| Surface Reflectance | Adjustment Factors |
|---|---|
| 3 % or less | 1.5 |
| 10% | 1.0 |
| 20% or more | 0.75 |

TABLE 3  LIGHTING SOURCE CHARACTERISTICS

| Source Types | Expected Life (hrs) | Lighting Efficiency (Lumens/Watt) | Wattage (Watt) |
|---|---|---|---|
| Tungsten | 1000 | 8 – 14 | Up to 1000 |
| Fluorescent | 6000 | 50 – 75 | Up to 250 |
| Sodium | 6000 | 100 – 120 | Up to 160 |
| Mercury | 7500 | 20 – 60 | Up to 400 |

TABLE 4  RECOMMENDED ARRANGEMENT OF STREET LIGHTING

| Type of Arrangement | Pavement Width |
|---|---|
| One side | Width <= 30ft |
| Both sides – Staggered | 30ft > Width <= 60ft |
| Both sides – Opposite | Width > 60ft |

FIGURE 1  CO-EFFICIENT OF UTILIZATION CURVES (FOR LIGHT DISTRIBUTION TYPE III)
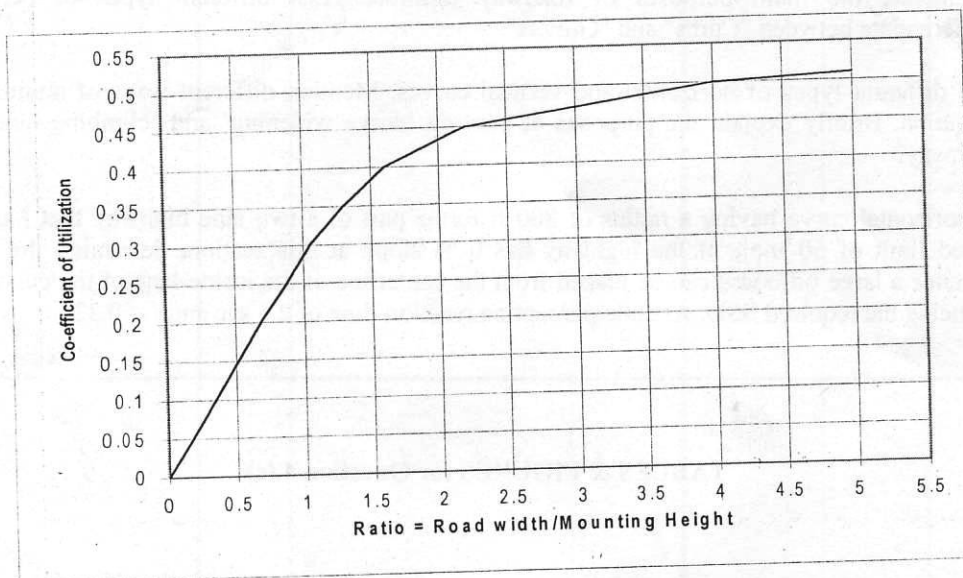


Note: Due to poor maintenance, the actual co-efficient of utilization is reduced by a factor usually 0.8 (i.e. taken as 80%).