SIXTH SEMESTER B.E. DEGREE EXAMINATION, JUNE / JULY 2018
TRAFFIC ENGINEERING

10CV667

USN 1CR14CV051

Sixth Semester B.E. Degree Examination, June/July 2018
Traffic Engineering

Time: 3 hrs. Max. Marks:100

Note: *Answer FIVE full questions, selecting at least TWO questions from each part.*

PART – A

1 a. Define traffic engineering. What are the objectives of traffic engineering? Also explain the scope of traffic engineering. **(10 Marks)**

b. Discuss the road user characteristics in detail. **(10 Marks)**

2 a. What are the objectives of traffic volume studies? **(05 Marks)**

b. A vehicle was stopped in 1.8secs by fully applying the brakes and the skid marks measured 9.0m. Determine the average skid resistance. **(05 Marks)**

c. The table below summarises the field data obtained for spot speeds.

Speed Mid Class (Kmph)	25	35	45	55	65	75	85	95	105	115
No. of vehicles observed	7	20	35	52	63	40	27	13	6	3

Plot the analysed data and obtain the following :
i) Speed limit for traffic regulation
ii) Speed for geometric design. **(10 Marks)**

3 a. Explain the uses of i) Spot speed studies ii) Speed and delay studies. **(06 Marks)**

b. Discuss the purpose of parking studies. Explain the various aspects to be investigated during parking studies. **(08 Marks)**

c. List the applications of O and D studies. **(06 Marks)**

4 a. Define PCU. List the factors which affect the PCU values of different vehicle classes. **(06 Marks)**

b. Explain the various preventive measures to reduce accidents. **(06 Marks)**

c. A vehicle of weight 25 tonnes skids through a distance equal to 50m, before colliding with another parked vehicle of weight 2.5 tonnes. After collision both the vehicles skid through a distance equal to 13m before stopping if the coefficient of friction is 0.5, compute
i) Speed after collision
ii) Speed at collision
iii) Speed before collision. **(08 Marks)**

PART – B

5 a. Describe the Green – shield model of traffic flow. **(06 Marks)**

b. The data given below shows the occupancy of parking spaces in a parking lot consisting of 50 spaces. The count was taken at 15 min intervals during the 4 hours on 6 week days. Find whether the number of vacant spaces during any count follows a Poisson's distribution.

Occupancy of parking spaces	50	49	48	47	46	45	44	43	42	41	≤ 40
Frequency	6	15	21	20	15	10	5	2	1	1	0

(10 Marks)

c. Explain Goodness of fit test. **(04 Marks)**

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

6 a. The spot speeds at a particular location are normally distributed with a mean of 51.7kmph and a standard deviation of 8.3kmph. What is the probability that

i) Speed exceeds 65 kmph

ii) Speed lies between 40 and 70 kmph.

The values from normal distribution tables are

ϕ (1.6) = 0.952, ϕ (2.21) = 0.9864

ϕ (1.41) = 0.9207, ϕ (Z) = 0.85 for which Z = 1.04 **(10 Marks)**

b. Explain briefly: i) Phases of traffic regulation ii) Regulatory signs. **(10 Marks)**

7 a. List the advantages and disadvantages of traffic signals. **(06 Marks)**

b. The average normal flow on cross – roads A and B during design period are 500 and 300 PCU per hour. The saturation flow values on these roads are estimated as 1300 and 1000 PCU per hour respectively. The all red time required for pedestrian crossing is 13 secs. Design two phase traffic signal by Webster's method. **(10 Marks)**

c. Design a street lighting system for the following conditions. Lane width = 20m, mounting height = 7m, Lamp size = 8000 lumen, Luminance type = II. Assume coefficient of utilization as 0.44 and maintenance factor as 0.8. Calculate the spacing between lighting units to produce average Lux – 6.0 **(04 Marks)**

8 a. Define ITS. What are its applications in traffic engineering? **(06 Marks)**

b. Enumerate the design factors and the advantages of a rotary. **(08 Marks)**

c. Explain the various design factors in road lighting. **(06 Marks)**

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SOLUTION

PART –A

1. A. Define traffic engineering. What are the objectives of traffic engineering? Also explain the scope of traffic engineering.

Definition of Traffic Engineering :-

Traffic engineering is the branch of engineering which deals with the improvement of traffic performances of road by application of scientific principle tools, techniques and findings from traffic studies for safe., rapid, convenient and economic movement of people and goods.

Objectives of Traffic Engineering :-

The basic objective of Traffic engineering is to achieve efficient rapid flow of traffic by providing a safe ~~traffic~~ system for highway traffic and thus reducing the number of traffic accidents.

The additional objectives of Traffic engineering are

- Speed
- comfort
- convenience
- Economy
- Environmental compatibility

Scope of Traffic Engineering :-

It includes the following :-

i) Traffic characteristics :-

The study of Traffic characteristics is the most important pre-requisite for any improvement of Traffic facilities. The traffic characteristics include both road user characteristics and vehicular characteristics. The road users include pedestrians, motorists and cyclists using the road with the different motives.

ii) Traffic studies and Analysis:

Various studies carried on actual traffic include speed, volume, capacity, travel patterns, origin and destination, traffic flow characteristics, parking and accident studies

iii) Traffic operation - control and regulation:

It includes regulations, control and the warrants for application of controls. The regulations may be in the form of laws and ordinances or other traffic regulatory measures such as speed limits. Installation of traffic control devices such as signs, signals, islands are most common means of regulation

iv) Planning and Analysis:

Traffic planning is a separate phase for major highways, mass transit facilities and parking facilities. Transport planning includes formulation of proposals for safe and efficient movement of goods and people by understanding the nature of problems created by increased vehicle population.

v) Geometric Design:

All the aspects such as cross-section and surface details, sight distance requirements, horizontal and vertical alignment, manoeuvre areas and intersections and parking facilities are to be suitably designed for better performance.

vi) Administration and management:

The various phases of traffic engineering are implemented with the help of engineering, enforcement and education or '3 E's'. Enforcement is usually made through traffic laws, regulations and control. Education may be possible by sufficient publicity through media and schools. It aims at improving human factor in traffic performance. Engineering phase is one which is constructive. It deals with improvement of road geometrics, providing additional road facilities etc.

B. Discuss road user characteristics in detail.

Vision -

It is one of the important factors that affects almost all aspects of highway design and safety. It includes the acuity of vision, peripheral vision and eye movement, glare vision, glare recovery and depth judgement. Minimum standards for acuity of vision are laid down by licensing authorities. Field of clearest and acute vision is within a cone whose angle is only 3 degrees, ~~through the vision~~ about the centre of retina. This signifies that for very distant vision, the object should be within this narrow cone for satisfactory perception. and it is important for locating traffic signs & signals.

Peripheral vision is the total visual field for the two eyes, within which the eyes are able to see the objects, but without clear details and colour. The angle of peripheral vision is about 160° in the horizontal direction and 115° in the vertical direction. If the detailed attention is needed, the driver turns his head or eyes so that the object now comes within the cone of clear vision. The cone of peripheral vision also depends on speed. The angle of the cone falls down from about 110° @ 30 kmph to 40° @ 100 kmph speed.

Colour vision is important for discerning the traffic lights and colour schemes in traffic signs. The ability of the driver's eyes to adapt to glare due to head lights or to

2. A. What are the objectives of traffic volume studies?

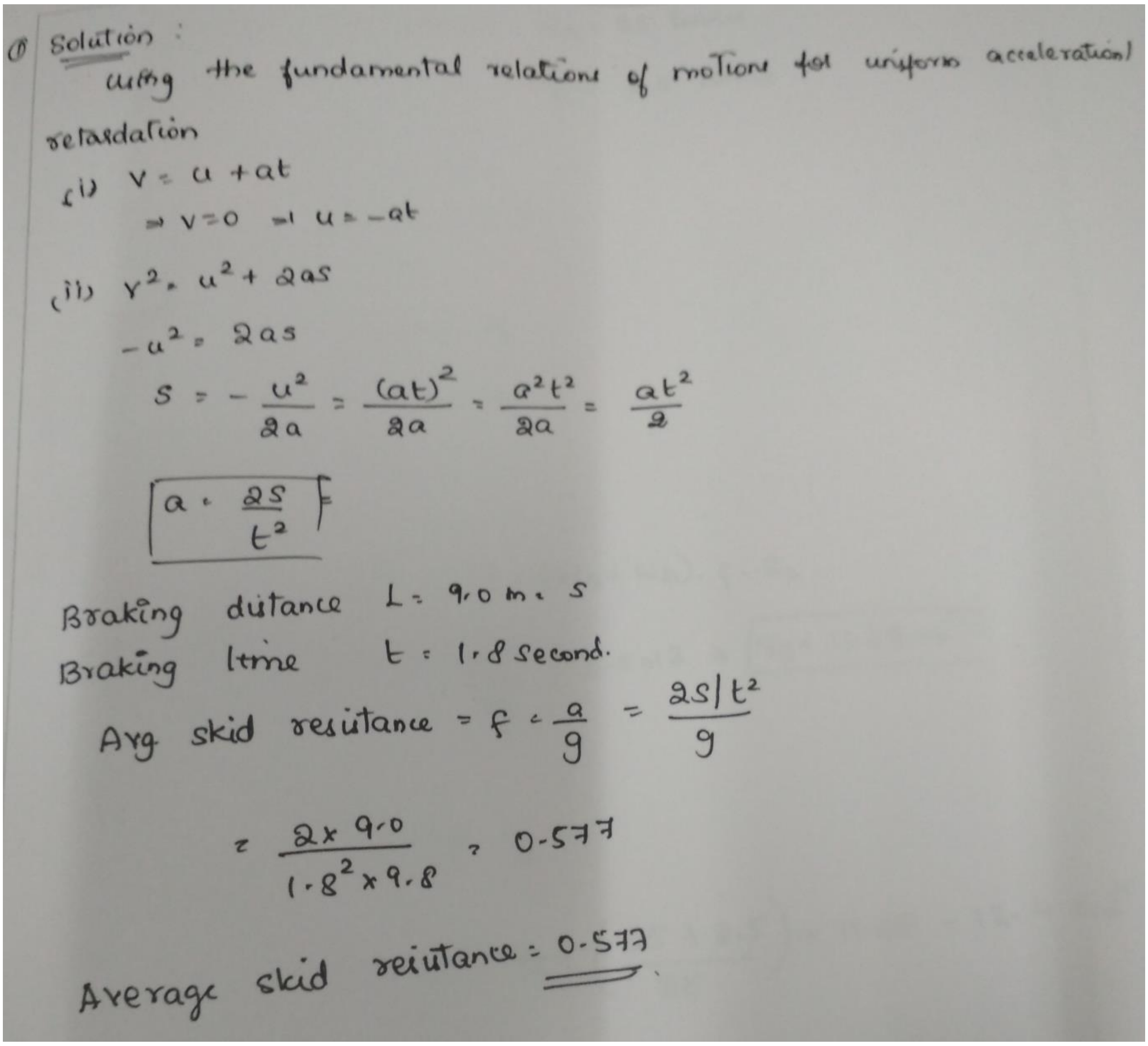
Traffic volume studies are conducted to determine the number, movements, and classifications of roadway vehicles at a given location. These data can help identify critical flow time periods, determine the influence of large vehicles or pedestrians on vehicular **traffic** flow, or document **traffic volume** trends.

Traffic volume studies –

- Objectives :
- Improvement of traffic system
- Understand the existing condition to forecast
- Maintenance
- Traffic regulation and control

Economic analysis

B. A vehicle was stopped in 1.8 sec by fully applying the brakes and the skid marks measured 9.0m. Determine the average skid resistance.



Solution :

using the fundamental relations of motion for uniform acceleration/retardation

(i) $v = u + at$

$\Rightarrow v = 0 \Rightarrow u = -at$

(ii) $v^2 = u^2 + 2as$

$-u^2 = 2as$

$s = -\frac{u^2}{2a} = \frac{(at)^2}{2a} = \frac{a^2t^2}{2a} = \frac{at^2}{2}$

$a = \frac{2s}{t^2}$

Braking distance $L = 9.0$ m $= s$

Braking time $t = 1.8$ second.

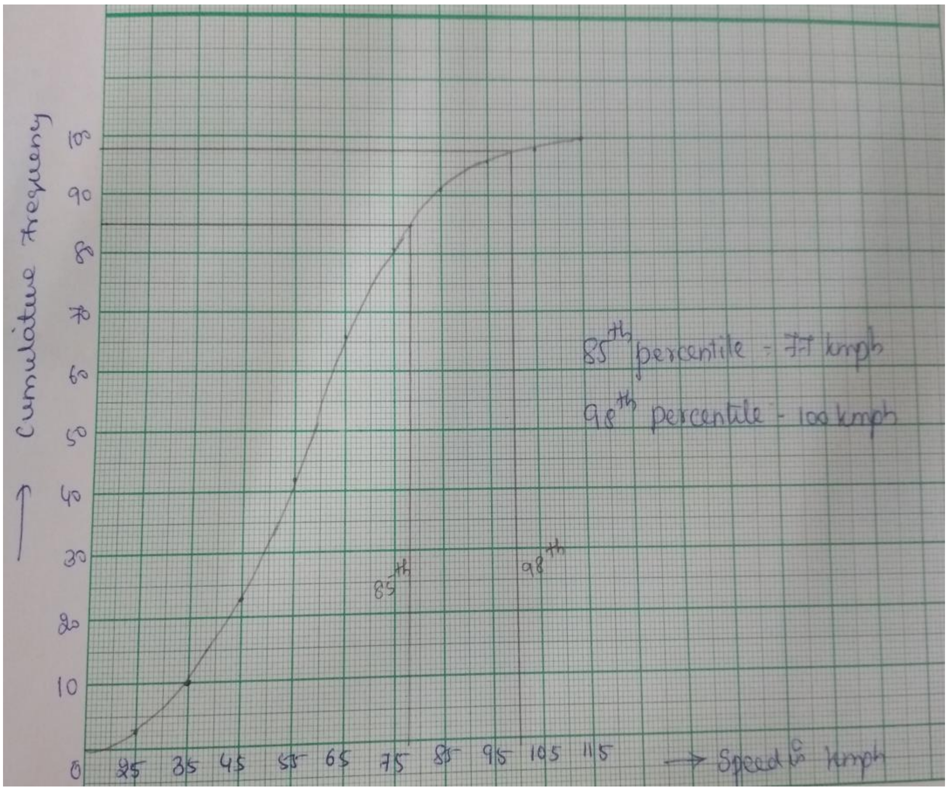
Avg skid resistance $= f = \frac{a}{g} = \frac{2s/t^2}{g}$

$= \frac{2 \times 9.0}{1.8^2 \times 9.8} = 0.577$

Average skid resistance = 0.577

C) (i) Speed limit for traffic regulation (ii) Speed for geometric design

Speed	Frequency	Total	% Frequency	Cumulative Frequency
25	7	266	2.63	2.63
35	20	266	7.52	10.15
45	35	266	13.16	23.31
55	52	266	19.55	42.86
65	63	266	23.68	66.54
75	40	266	15.04	81.58
85	27	266	10.15	91.73
95	13	266	4.89	96.61
105	6	266	2.26	98.87
115	3	266	1.13	100.00



From graph,

(i) Speed for traffic regulation = 85th percentile = 77kmph

(ii) Speed for geometric design = 98th percentile = 100 kmph

3. A. Explain the uses of (i) Spot speed studies (ii) Speed and delay studies

(i) Spot speed studies :

A spot speed is made by measuring the individual speeds of a sample of the vehicle passing a given spot on a street or highway. Spot speed studies are used to determine the speed distribution of a traffic stream at a specific location. The data gathered in spot speed studies are used to determine vehicle speed percentiles, which are useful in making many speed-related decisions. Spot speed data have a number of safety applications, including the following

- Speed trends,
- Traffic control planning,
- Accidental analysis,
- Geometric design,
- Research studies.

(ii) Speed and delay studies:

Speed and travel time are the most commonly used indicators of performance for traffic facilities and networks. Delays are often used to measure the performance of traffic flow at intersections.

- The purpose of a Travel Time and Delay Study is to evaluate the quality of traffic movement along a route and determine the locations, types, and extent of traffic delays by using a moving test vehicle.
- This study method can be used to compare operational conditions before and after roadway or intersection improvements have been made. It can also be used as a

tool to assist in prioritizing projects by comparing the magnitude of the operational deficiencies (such as delays and stops) for each project under consideration.

- The Travel Time and Delay Study can also be used by planners to monitor level of service for local government comprehensive plans.
- The methodology presented herein provides the engineer with quantitative information with which he can develop recommendations for improvements such as traffic signal re-timing, safety improvements, turn lane additions, and channelization enhancements

b. Discuss the purpose of parking studies. Explain the various aspects to be investigated during parking studies.

Before taking any measures for the betterment of conditions, data regarding availability of parking space, extent of its usage and parking demand is essential. It is also required to estimate the parking fares also. Parking surveys are intended to provide all these information. Since the duration of parking varies with different vehicles, several statistics are used to access the parking need. The following parking statistics are normally important.

1. **Parking accumulation**: It is defined as the number of vehicles parked at a given instant of time. Normally this is expressed by accumulation curve. Accumulation curve is the graph obtained by plotting the number of bays occupied with respect to time.

2. **Parking volume**: Parking volume is the total number of vehicles parked at a given duration of time. This does not account for repetition of vehicles. The actual volume of vehicles entered in the area is recorded.

3. **Parking load** : Parking load gives the area under the accumulation curve. It can also be obtained by simply multiplying the number of vehicles occupying the parking area at each time interval with the time interval. It is expressed as vehicle hours.

4. **Average parking duration**: It is the ratio of total vehicle hours to the number of vehicles parked.

$$\text{parking duration} = \frac{\text{parking load}}{\text{parking volume}} \tag{41.1}$$

5. **Parking turnover**: It is the ratio of number of vehicles parked in a duration to the number of parking bays available. This can be expressed as number of vehicles per bay per time duration.

$$\text{parking turnover} = \frac{\text{parking volume}}{\text{no. of bays available}} \tag{41.2}$$

6. **Parking index**: Parking index is also called occupancy or efficiency. It is defined as the ratio of number of bays occupied in a time duration to the total space available. It gives an aggregate measure of how effectively the parking space is utilized. Parking index can be found out as follows

$$\text{parking index} = \frac{\text{parking load}}{\text{parking capacity}} \times 100 \tag{41.3}$$

C. List the applications of O and D studies.

Uses of OD data:

- To determine the amount of by-passable traffic that enters a town ---need for a by-pass
- To develop trip generation and trip distribution models in transport planning process
- To determine the extent to which the present highway system is adequate and to plan for new facilities
- To assess the adequacy of parking facilities and to plan for future

4. A. Define PCU. List the factors which affect the PCU values of different vehicle classes.

Passenger Car Unit (PCU)

Different classes of vehicles such as cars, vans, buses, trucks, auto rickshaw, motor cycles, pedal cycles etc. are found to use the common roadway facilities without segregation. The flow of traffic with unrestricted mixing of different vehicle classes forms the 'Mixed Traffic Flow'. In a mixed traffic condition, the traffic flow characteristics are very much complex when compared to homogeneous traffic consisting of passenger cars only. It is very difficult to estimate the traffic volume and capacity of roadway facilities under mixed traffic flow. Hence the different vehicle classes are converted to one common standard vehicle unit.It is common practice to consider the passenger car as the standard vehicle unit to convert the other vehicle classes and this unit is called Passenger Car Unit (or) PCU. Thus in a mixed traffic flow, traffic volume and capacity are generally expressed as pcu / hr (or)pcu / lane/ hr and traffic density as pcu / km length of lane.

Factors affecting PCU Values:

- Vehicles characteristics such as dimensions, power, speed, acceleration and braking characteristics.
- Transverse and longitudinal gaps (or) clearances between moving vehicles which depends upon speed, driver characteristics.
- Traffic stream characteristics such as composition of different vehicle classes, mean speed and speed distribution of mixed traffic stream, volume to capacity ratio etc.
- Roadway characteristics such as road geometrics includes gradient, curve etc., rural or urban road, presence of intersections and the types of intersections.
- Regulation and control of traffic such as speed limit, one-way traffic, presence of different traffic control devices etc.
- Environmental and climatic conditions

PCU values suggested by IRC:

Sl. no.	Vehicle class	PCU Values
1.	Passenger car, Auto rickshaw, Tempo, agricultural tractor	1.0
2.	Bus, Truck , agricultural tractor-tailer unit	3.0
3.	Motor cycle, scooter and pedal cycle	0.5
4.	Cycle rickshaw	1.5
5.	Horse drawn vehicles	4.0
6.	Small bullock cart and hand cart	6.0
7.	Large bullock cart	8.0

b. Explain the various preventive measures to reduce accidents.

The various measures of engineering that may be useful to prevent accidents are enumerated below

- Visual guidance to driver
- Road reconstruction
- Channelization
- Road signs
- Street lighting
- Improvement in skid resistance
- Road markings
- Guide posts with or without reflector
- Guard rail
- Driver reviver stop
- Constructing flyovers and bypass
- Regular accident studies

C. A vehicle of weight 25 tonnes skids through a distance equal to 50m, before colliding with another parked vehicle of weight 2.5 tonnes. After collision both the vehicles skid through a distance equal to 13m before stopping if the coefficient of friction is 0.5m, Compute

(i) Speed after collision

(ii) Speed at collision

(iii) Speed before collision

Weight of moving vehicle W_a = 25 tonnes

Weight of parked vehicle W_b = 2.5 tonnes

Skid distance = S_1 = 50 m

Skid distance = S_2 = 13 m

Friction co-efficient = 0.5.

Let Initial speed = V_1

Speed before collision = V_2

Speed after collision = V_3

Final speed $V_4 = 0$

a) After collision :

$$\frac{(W_a + W_b)}{2g} \cdot (V_3^2 - V_4^2) = (W_a + W_b) \cdot f \cdot S_2$$

$$V_4 = 0 \Rightarrow \frac{V_3^2}{2g} = 0.5 \times 13 \Rightarrow \boxed{V_3 = 11.28\ ms^{-1}}$$

b) At collision :

$$\frac{W_a \cdot V_2}{g} = \frac{W_a + W_b}{g} \cdot V_3$$

$$V_2 = \frac{W_a + W_b}{W_a} \cdot V_3 = \left(\frac{25 + 2.5}{25}\right) \times 11.28 = 12.4\ ms^{-1}$$

$$\boxed{V_2 = 12.4\ ms^{-1}}$$

c) Before collision :

$$V_1 = \sqrt{2g \times 0.5 \times S_1 + V_2^2}$$

$$V_1 = \sqrt{2 \times 9.81 \times 0.5 \times 50 + 12.4^2}$$

$$\boxed{V_1 = 25.37\ ms^{-1}} \quad \boxed{V_1 = 91.34\ kmph}$$

5. A. Describe Green shield model of traffic flow.

Macroscopic stream models represent how the behaviour of one parameter of traffic flow changes with respect to another. Most important among them is the relation between speed and density. The first and most simple relation between them is proposed by Greenshield. Greenshield assumed a linear speed-density relationship as illustrated in figure 3:1 to derive the model. The equation for this relationship is shown below.

$$v = v_f - \left[\frac{v_f}{k_j}\right].k \tag{3.1}$$

where v is the mean speed at density k, v_f is the free speed and k_j is the jam density. This equation (3.1) is often referred to as the Greenshield's model. It indicates that when density becomes zero, speed approaches free flow speed (ie. $v \rightarrow v_f$ when $k \rightarrow 0$). Once the relation between speed and flow is established, the relation with flow can be derived. This relation between flow and density is parabolic in shape and is shown in figure 3:3. Also, we know that

$$q = k.v \tag{3.2}$$

Now substituting equation 3.1 in equation 3.2, we get

$$q = v_f.k - \left[\frac{v_f}{k_j}\right] k^2 \tag{3.3}$$

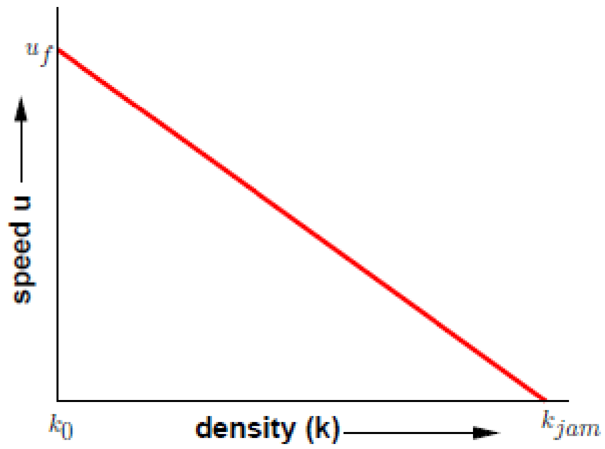


Figure 3:1: Relation between speed and density

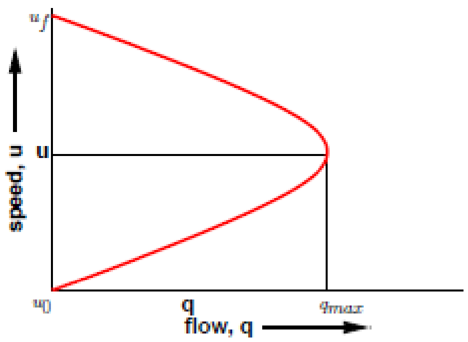


Figure 3:2: Relation between speed and flow

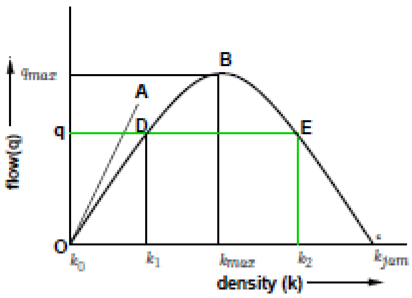


Figure 3:3: Relation between flow and density 1

B. Data given below shows the occupancy of parking spaces in a parking lot consisting of 50 spaces. The count was taken at 15 min intervals during the 4 hours on 6 week days. Find whether the number of vacant spaces during any count follows a poisson distribution.

Occupancy	50	49	48	47	46	45	44	43	42	41	≤40
Frequency	6	15	21	20	15	10	5	2	1	1	0

Solution:

No. of vacant spaces	Observed Frequency	Total no. of vacant spaces	Theoretical Probability of stated no. of vacant spaces	Theoretical frequency of no. of vacant spaces
0	6	0	0.0498	4.8
1	15	15	0.1494	14.3
2	21	42	0.2241	21.5
3	20	60	0.2241	21.5
4	15	60	0.1681	16.5
5	10	50	0.1009	9.6
6	5	30	0.0505	4.8
7	2	14	0.0216	2.1
8	1	8	0.0081	0.8
9	1	9	0.0027	0.3
10 or more	0	0	0.0007	0.1
Total	96	288	1.0000	96.0

Inspection of columns indicates a fair agreement between observed and theoretical frequencies. Hence it can be concluded that the number of vacant spaces follows Poisson distribution.

c. Explain "goodness of fit" test.

Goodness-of fit test.

The measure of the discrepancy between a set of observed ta and the values that are to be expected if the results llow a hypothesis distribution is evaluated.

The χ^2 value is estimated from

$$\chi^2_{(obs)} = \sum_{j=1}^{c} \frac{(O_j - E_j)^2}{E_j}$$

O_j = Observed frequency of the j^{th} class or event as per hypothesized distribution

E_j : Expected frequency " "

c : No. of classes or events

The degree of freedom, υ, for a goodness-of-a fit epends upon the particular type of distribution being tested. Given by number of classes or events (c) minus the number parameters that were utilized from the observed data to calculate the theoretical values. The following table gives the degrees of freedom for various distributions.

Distribution	Degrees of freedom
Binomial	$c-2$
Normal	$c-3$
Poisson	$c-2$
Exponential	$c-2$

When the individual values of the expected frequencies are small, it is usual to re-group some of these classes so that the theoretical frequency is not less than about 5.

6. a. The spot speeds at particular location are normally distributed with a mean of 51.7 kmph and a standard deviation of 8.3 kmph. What is the pobablility that (i) Speed exceeds 65kmph. (ii) Speed lies between 40 and 70 kmph.

1. Probability that speed exceeds 65kmph is the area under the normal curve to the right of x=65 kmph

The standard normal variable $z = (x - \mu) / \sigma$

$= (65-51.7) / 8.3 = 1.6$

From the statistical table, $\Phi (Z) = \Phi (1.6)$

$\Phi (1.6) = 0.9542$

$P (x \geq 65) = 1 – 0.9452 = 0.0548$ = 5.48 percent

B) Probability that speeds lie between 40 and 70 kmph

$= P (40 < x < 70) = \Phi (Z_2) – \Phi(Z_1)$

$Z_2 = (70 +51.7) / 8.3 = 2.21$

$Z_1 = (40 – 51.7) / 8.3 = (-1.41)$

From the statistical table,

$\Phi (Z_2) = \Phi (2.21) = 0.9864$

$\Phi (Z_1) = \Phi (-1.41) = 1- \Phi (1.41) = 1 – 0.9207 = 0.0793$

$P(40 < x < 70) = \Phi(Z_2) - \Phi(Z_1)$

$= 0.9864 - 0.0793 = 0.9071 = 90.71$ percent

b. Explain briefly (i) Phases of traffic regulation (ii) Regulatory signs

(i) Phases of traffic regulation

The first phase of traffic regulation is driver controls followed by vehicle control, traffic flow regulation and general control.

Regulation concerning driver

- Licensing of the driver
- Requirements of physical fitness
- Age of drivers
- Disqualification and endorsement of licences
- Offences and penalties

Traffic control :

- One way
- Traffic markings
- Traffic signs
- Traffic signals
- Traffic rotaries
- Street lighting
- Road side furniture
- Matters dealing with control of vehicles, drivers and road users
- Vehicles – registration, weight, size, design, construction and maintenance
- Drivers –issue of license and other operations of vehicles
- Road users – pedestrians, cyclists and motor cyclists

Regulation concerning vehicles

- Speed limit

Factors:
Speed of traffic
Road conditions
Environment of the road
Volume of Traffic
Accident rates

(ii) Regulatory signs

❖ Prohibitory signs

- Definite Negative Instructions
- Denotes Prohibition To Movement
- TYPES:

➢ Movement Prohibition
➢ Waiting Prohibition
➢ Restrictions On Dimensions, Weight Or Speed Of The Vehicle

- CIRCULAR SHAPE - DIAMETER STANDARD SIZE- 0.6m
  REDUCED SIZE – 0.4m
- Red border
- Background – White (speed control)
  - blue (Waiting and parking)
  - blue (direction control and other signs)
- Symbols – prohibitory signs – black
  - direction control signs – white

❖ Mandatory signs
• Definite positive instructions
✓ Stop sign
✓ Yield or give way sign
• Should use
✓ Intersection of less important road with a main road
✓ Street entering a through highway or street
✓ Un signalised intersection in a signalised area
✓ Serious accident record
• Should not use
❖ through roadways or expressways
❖ Speed control
❖ At signalised intersections
• Octagon
• Border- white
• Background – red
• Side of octagon - std size – 900mm
  - Reduced size – 600mm
• Definition plate – STOP sign message

7. (a) List the advantages and disadvantages of traffic signals.

Advantages of traffic signals:

Traffic signals control vehicle and pedestrian traffic by assigning priorities to various traffic movements to influence traffic flow. Properly designed, located and maintained traffic signals have one or more of these advantages:

• Provide for orderly movement of traffic;
• Increase traffic-handling capacity of an intersection;
• Reduce frequency and severity of certain types of crashes, especially right-angle collisions;
• Provide for continuous movement of traffic at a definite speed along a given route;
• Interrupt heavy traffic at intervals to permit other vehicles or pedestrians to cross.

Disadvantages of traffic signals:

Traffic signals are not a solution for all traffic problems at intersections, and unwarranted signals can adversely affect the safety and efficiency of traffic by causing one or more of the following:

• Excessive delay;
• Increased traffic congestion, air pollution and gasoline consumption;
• Disobedience of signals;
• Increased use of less-adequate streets to avoid traffic signals;
• Increased frequency of crashes, especially rear-end collisions.

(b) The average normal flow on cross-roads A and B during design period are 500 and 300 PCU per hour. The saturation flow values on these roads are estimated as 1300 and 1000 PCU per hour respectively. The all red time required for pedestrian crossing is 13seconds. Design two phase traffic signal by Webster’s method.

(1) The average normal flow on cross-roads A and B during design period are 500 and 300 PCU per hour. The saturation flow values on these roads are estimated as 1300 and 1000 PCU per hour respectively. The all red time required for pedestrian crossing is 13 secs. Design a two phase Traffic signal by Webster's Method.

Solution:

$$Y_a = \frac{q_a}{S_a} = \frac{500}{1300} = 0.385$$

$$Y_b = \frac{q_b}{S_b} = \frac{300}{1000} = 0.3$$

$Y = Y_a + Y_b = 0.385 + 0.3 = 0.685$

$L = 2n + R = 2\times2 + 13 = 17$ seconds

$$C_o = \frac{1.5L+5}{1-Y} = \frac{(1.5\times17)+5}{1-0.685} = 41.37 \text{ sec.}$$

$$G_a = \frac{Y_a}{Y}(C_o - L) = \frac{0.385}{0.685}(41.37-17) = 13.7 \text{ s.}$$

$$G_b = \frac{Y_b}{Y}(C_o - L) = \frac{0.3}{0.685}(41.37-17) = 10.67 \text{ s.}$$

Providing amber time of 2 seconds, each for clearance

Total cycle time = 13.7 + 10.67 + 13 + 4 = 41.37 s.

(c) Design a street lighting system for the following conditions. Lane width – 20m, mounting height= 7m, Lamp size = 8000lumen, Luminance type = 11. Assume coefficient the spacing between lighting units to produce average lux=6.0
The ratio of Pavement width / Mounting height = (20/7) = 2.86
Hence Coefficient of utilization = 0.48
Assume maintenance factor = 0.8

Spacing = (Lamp Lumen * Coefficient of utilization * maintenance factor) / (Average Lux * Width of road)
= (8000*0.48*0.8) / (6 * 20)
= 25.6m

8. A) Define ITS. What are its applications in traffic engineering?

Definition:

Intelligent Transport Systems (ITS) are transport systems that apply modern information technologies to improve the operation of transport networks. The systems acquire vast volume of data on various aspects of transport operation such as traffic volume, speed, headway & load carried, process them and apply the result to guide traffic, improve operations enhance safety and transport costs

Application of ITS:

ITS has the following variety of applications:

- Monitoring traffic flow, provide information to drivers on the congestion on the road, road closures, alternative routes, weather conditions and speeds to be observed. Advanced Traveller Information System (ATIS) gives the information to highway users on traffic jams, road closures, alternative routes and weather condition.

- Monitoring incidents on the road, such as vehicle break-down and collisions:

- Electronic collection of toll.

- Intelligent Vehicle-Highway System (IVHS), in which vehicles are guided longitudinally and laterally by the use of electronic devices. The advanced Vehicle Control Systems (AVCS) dispense with human control of vehicles and rely on computers

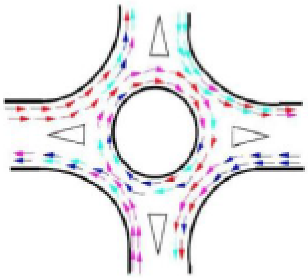
- Traffic control on urban streets by using information on traffic flows and adjusting the signal operations to reduce congestion and delay.

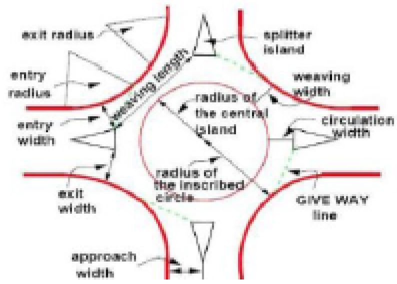
- Asset Maintenance Management Systems (AMMS) cover the data on assets, the traffic using the asset,

b) Enumerate the design factors and the advantages of a rotary.

Ans: The design elements include design speed, radius at entry, exit and the central island, weaving length and width, entry and exit widths. In addition the capacity of the rotary can also be determined by using some empirical formulae. A typical intersection is shown in figure

Design speed: All the vehicles are required to reduce their speed at a rotary. Therefore, the design speed of a rotary will be much lower than the roads leading to it. Although it is possible to design roundabout without much speed reduction, the geometry may lead to large size incurring huge cost of construction. The normal practice is to keep the design speed as 30 and 40 kmph for urban and rural areas respectively





Entry, exit and island radius: The radius at the entry depends on various factors like design speed, super elevation, and coefficient of friction. The entry to the rotary is not straight, but a small curvature is introduced. This will force the driver to reduce the speed. The speed range of about 20 kmph and 25 kmph is ideal for a radius and the radius of the rotary island so that the vehicles will discharge from the rotary at a higher rate. A general practice is to keep the exit radius as 1.5 to 2 times the entry radius. However, if pedestrian movement is higher at the exit approach, then the exit radius could be set as same as that of the entry radius. The radius of the central island is governed by the design speed, and the radius of the entry curve. The radius of the central island, in practice, is given a slightly higher reading so that the movement of the traffic already in the rotary will have priority of movement. The radius of the central island which is about 1.3 times that of the entry curve is adequate for all practical purposes.

Width of the rotary: The entry width and exit width of the rotary is governed by the traffic entering and leaving the intersection and the width of the approaching road. The width of the carriageway at entry and exit will be lower than the width of the carriageway at the approaches to enable reduction of speed. IRC suggests that a two lane road of 7m width should be kept as 7m for urban roads and 6.5m for rural roads. Further, a three lane road of 10.5m is to be reduced to 7 and 7.5m respectively for urban and rural roads. The width of the weaving section should be higher than the width at entry and exit. Normally this will be one lane more than the average entry and exit width. Thus weaving width is given as, W weaving

, W weaving = (e1 + e2)   3.5m

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Where e_1 is the width of the carriageway at the entry and e2 is the carriageway width at exit. Weaving length determines how smoothly the traffic can merge and diverge. It is decided based on many factors such as weaving width, proportion of weaving traffic to the non-weaving traffic etc. This can be best achieved by making the ratio of weaving length to the weaving width very high. A ratio of 4 is the minimum value suggested by IRC. Very large weaving length is also dangerous, as it may encourage over-speeding

Capacity: The capacity of rotary is determined by the capacity of each weaving section. Transportation road research lab (TRL) proposed the following empirical formula to find the capacity of the weaving section

$$Q_w = \frac{280w[1 + \frac{e}{w}][1 - \frac{p}{3}]}{1 + \frac{w}{l}}$$

Where e is the average entry and exit width, i.e., $(e_1+e_2)/2$, w is the weaving width, l is the length of weaving, and p is the proportion of weaving traffic to the non-weaving traffic. Shows four types of movements at a weaving section, a and d are the non-weaving traffic and b and c are the weaving traffic. Therefore

$$p = \frac{b + c}{a + b + c + d}$$

The key advantages of the rotary intersection are listed below:

- Traffic flow is regulated to only one direction of movement, thus eliminating severe conflicts between crossing movements.
- All the vehicles entering the rotary are gently forced to reduce the speed and continue to move at slower speed. Thus, more of the vehicles need to be stopped.
- Because of lower speed of negotiation and elimination of severe conflicts, accidents and their severity are much less in rotaries.
- Rotaries are self-governing and do not need practically any control by police or traffic signals.
- They are ideally suited for moderate traffic, especially with irregular geometry, or intersections with more than three or four approaches.

c) Explain the various design factors in road lighting.

The factors responsible for the lighting scheme for roads are:

i. Luminance Level.
ii. Luminance Uniformity.
iii. Degree of Glare limitation.
iv. Lamp Spectra and
v. Effectiveness of visual guidance.

Luminance Level: As the Luminance of a road influences contrast sensitivity of drivers' eyes and contrast of obstacles, relative to back ground. Hence affects performance of Road users. Surrounding brightness affects the adaptation of human eye. Bright surroundings lower contrast sensitivity there by requiring higher luminance for the road surface. Darker surroundings make driver adapted to road (assuming road is brighter). Roads with dark surrounds are to be lit by including surroundings. Otherwise drivers cannot perceive objects in the surroundings. CIE 12 recommends that 5m away from the road on either side should be lit by illuminance level at least 50% of that on the road.

Luminance Uniformity Adequate uniformity is necessary for visual performance and visual comfort of the user. From visual performance view point, uniformity ratio is defined by $U0 = Lmin / Lavg$ .U0 should not be below 0.4. From visual comfort view point uniformity ratio is defined as $U1 = Lmin / Lmax$ measured along the line passing through the observer positioned in the middle of the traffic facing the traffic flow. Termed longitudinal uniformity ratio.

Glare Limitation Physiological or disability glare affect visual performance. Psychological or discomfort glare affect visual comfort. Glare is to be avoided at all costs.

Lamp Spectra : Spectral composition determines color appearance of the lamp. The way lamp is going to render color to objects Low pressure sodium vapour lamps give greater visual acuity. Spectrum should be such; there is Great speed of perception, less discomfort glare and shorter recovery time after glare.

Visual Guidance Visual guidance guides the road user and hence must for user to get a recognizable picture of the course immediately. This is improved by lamp arrangement that follows the run of the road. More so if turns and intersections are there. Lighting scheme must provide visual guidance. On roads having separate lanes with a separator the lighting columns are located on the separator. As is the custom in large avenues in Metros, on a curve the lighting column is located along the outer column. This gives a clear indication of the run of the road on the curvature. Visual guidance pilots traffic through lights of different colors on different routes. Exits on main roads are lit differently. Sodium vapour lamps for the main road and mercury lights for exits are employed.