CBCS SCHEME

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17CV561

Fifth Semester B.E. Degree Examination, Jan./Feb. 2021
Traffic Engineering

Time: 3 hrs. Max. Marks: 100

Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
2. Assume any missing data suitably.

Module-1

1 a. List the different road users characteristics and explain the concept of PIEV theory. **(10 Marks)**

b. Explain the fundamentals of traffic flow. **(10 Marks)**

OR

2 a. What are the different vehicular characteristics which affect road design and explain briefly? **(10 Marks)**

b. Discuss various urban traffic problem that India is facing. List some remedial measures also. **(10 Marks)**

Module-2

3 a. List out the objectives of traffic volume studies and origin destination studies. **(10 Marks)**

b. Following data were obtained from the spot speed studies. Determine:
i) Upper and lower values of speed limit for regulation
ii) Design speed for checking the geometric design element of the highway.

Speed range (kmph)	Number of vehicles	Speed range (kmph)	Number of Vehicles
5 to 10	230	30 to 35	430
10 to 15	375	35 to 40	290
15 to 20	500	40 to 50	110
20 to 25	680	50 to 60	25
25 to 30	525	60 to 70	8

(10 Marks)

OR

4 a. Explain briefly speed and delay study by moving car method. **(10 Marks)**

b. From the following data determine:
i) Speed limit values for mixed traffic
ii) Speed for geometric design

Speed (kmph)	Frequency	Speed (kmph)	Frequency
0 to 10	12	50 to 60	225
10 to 20	18	60 to 70	119
20 to 30	68	70 to 80	43
30 to 40	89	80 to 90	33
40 to 50	204	90 to 100	9

(10 Marks)

Module-3

5 a. Enumerate the design factors and advantages of rotary intersection. **(10 Marks)**

b. Write short notes on: i) At-grade intersection ii) Channelized intersection. **(10 Marks)**

OR

6 a. What are the advantages and disadvantages of traffic signal? **(10 Marks)**

b. The average normal flow of traffic on cross roads A and B during design period are 410 and 260 pcu per hour. The saturation flows are 1260 and 1000 pcu per hour respectively. The all red time required for pedestrian crossing is 12 seconds. Design a two phase traffic signal by Webster's method. **(10 Marks)**

Module-4

7 a. Briefly explain the various causes of accidents. **(10 Marks)**

b. Explain various design factors of highway lighting. **(10 Marks)**

OR

8 a. Explain the measure to control the traffic noise. **(10 Marks)**

b. Explain briefly promotion of non-motorized transport. **(10 Marks)**

Module-5

9 a. Explain intelligent transport system for traffic management. **(10 Marks)**

b. Discuss the details of traffic system management. **(10 Marks)**

OR

10 Write short notes on the following:

a. Traffic Congestion

b. Road Pricing System

c. Travel Demand Management

d. Traffic Regulatory Measures. **(20 Marks)**

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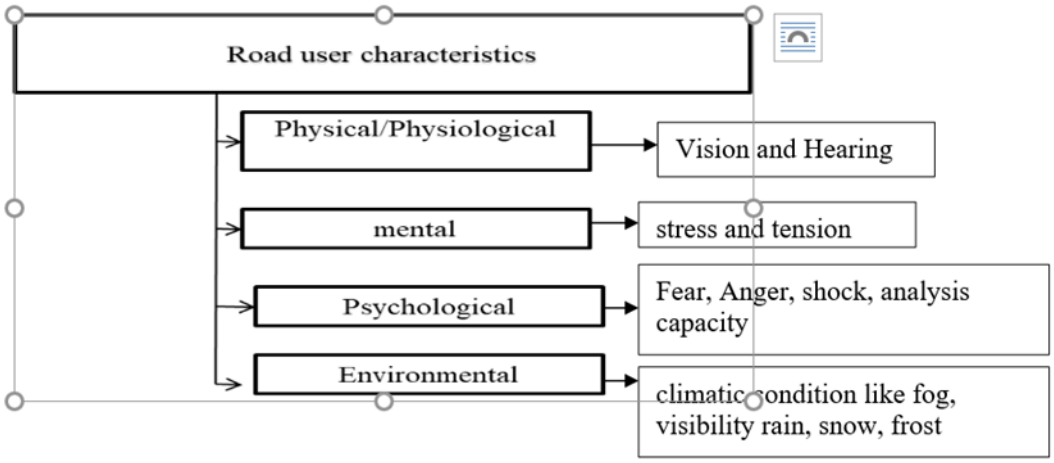
Fifth Semester B.E. Degree Examination, Dec 2020/Jan 2021

17CV561: Traffic Engineering

MODULE 1	
1a	**List the different road users characteristics and explain the concèpt of PIEV theory. (10 Marks)**



Vision:

Acute or clear vision cone-3º to 10º around the line of sight; legend can be read only within this narrow field of vision.

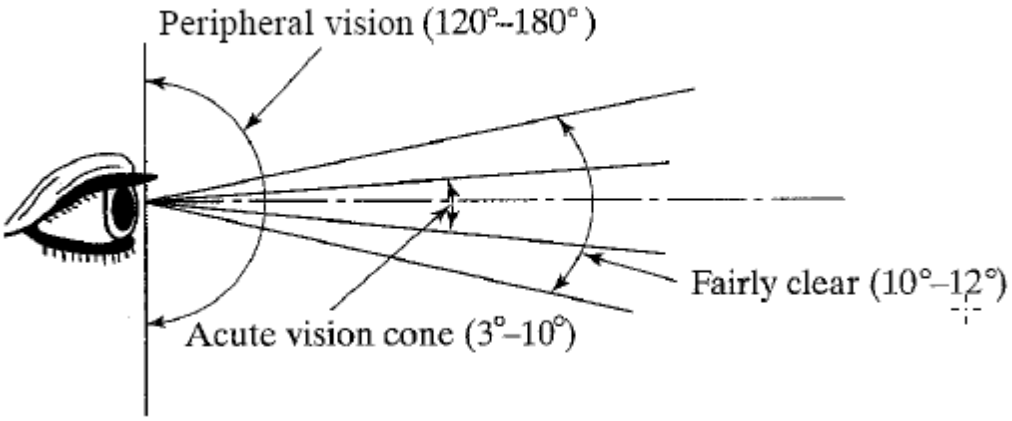
- Traffic signs are placed with in acute vision field
- Driver can see without changing his sight

Fairly clear vision cone-10º to 12º around the line of sight; color and shape can be identified in this field.

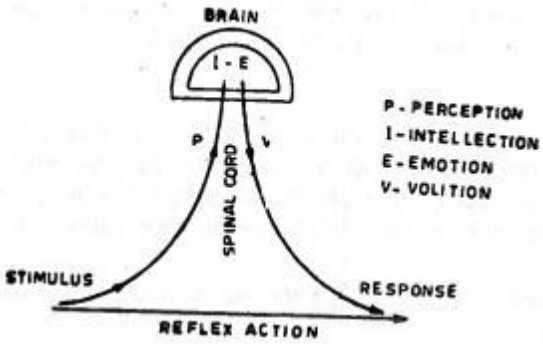
- Color and shapes can be identified

Peripheral vision-This field may extend up to 90º to the right and left of the centerline of the pupil, and up to 60º above and 70º below the line of sight.

- Stationary objects can not be detected but moving object can be
- Peripheral vision helps the driver for judgment of speed of moving vehicle



Hearing: Sound of nearing vehicles can alert the pedestrian. Elderly people with falling eye sight can better perceive through hearing.

	PIEV theory: It splits the reaction time of driver into 4 components. Perception : time required to perceive an object or situation. [function of eyes, ears] Intellection : time required for understanding the situation. [function of brain] Emotion : based on our emotions at the time [fear, anger etc] we reach the decision weather we want to stop or not. [function of brain] Volition : once the decision of stopping has been finalised, time required for moving the foot from the gas to the brake peddle. [Obeying orders of brain; function of legs and hands.  Reaction time of a driver is the time taken by a driver to respond to a situation and it is the sum of lag distance and brake distance. Lag distance is the distance travelled by the vehicle during the time taken by brain of a driver to understand a situation and brake distance is the distance travelled by the vehicle during the response time of the driver.
1b	**Explain the fundamentals of traffic flow. (10 marks)**
	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. Also, traffic flow q can be related to traffic density and traffic speed as q=kv. The first and most simple relation between them is proposed by Greenshield. Greenshield assumed a linear speed-density relationship as illustrated in figure 1 to derive the model. The equation for this relationship is shown below. $$v = v_f - \left[\frac{v_f}{k_j}\right].k$$ where v is the mean speed at density k, v_f is the free speed and k_j is the jam density. This above equation is often referred to as the Greenshields' model. It indicates that when density becomes zero, speed approaches free flow speed.

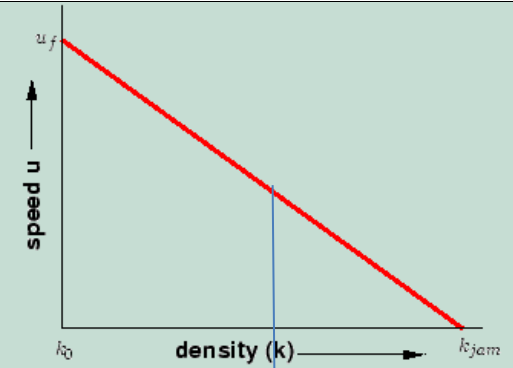


Figure 1: Relation between speed and density

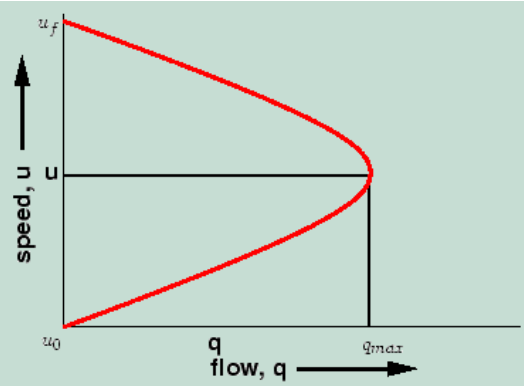


Figure 2: Relation between speed and flow

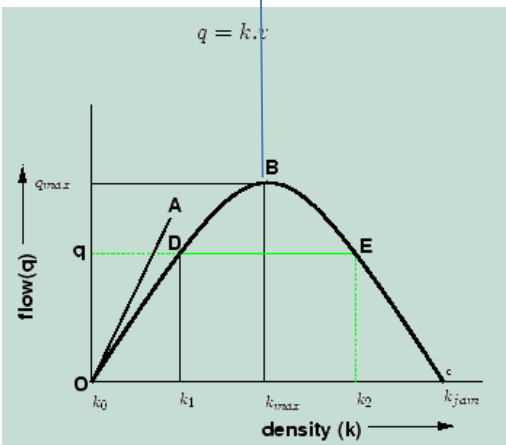


Figure 3: Relation between flow and density

Similarly when the traffic flow is very less, no vehicle itself, hence speed will be less. As traffic flow increases, speed increases, and after a peak with more traffic flow, interaction between the vehicles increases and speed decreases. Along with traffic density increases and reaches jam density. This is presented in Fig. 2.

Density Vs Flow:

- When **density is zero**, **flow** will also be **zero**, since there is no vehicles on the road.
- When the number of vehicles gradually increases the density as well as flow increases.
- When more and more vehicles are added, it reaches a situation where vehicles can't move. This is referred to as the **jam density** or the maximum density.
- At jam density, flow will be zero because the vehicles are not moving.
- There will be some density between zero density and jam density, when the flow is maximum. The relationship is normally represented by a parabolic curve
- O refers to the case with zero density and zero flow.
- The point C refers to the maximum density k_{jam} and the corresponding flow is zero.
- OA is the tangent drawn to the parabola at O, and the slope of the line OA gives the mean free flow speed.

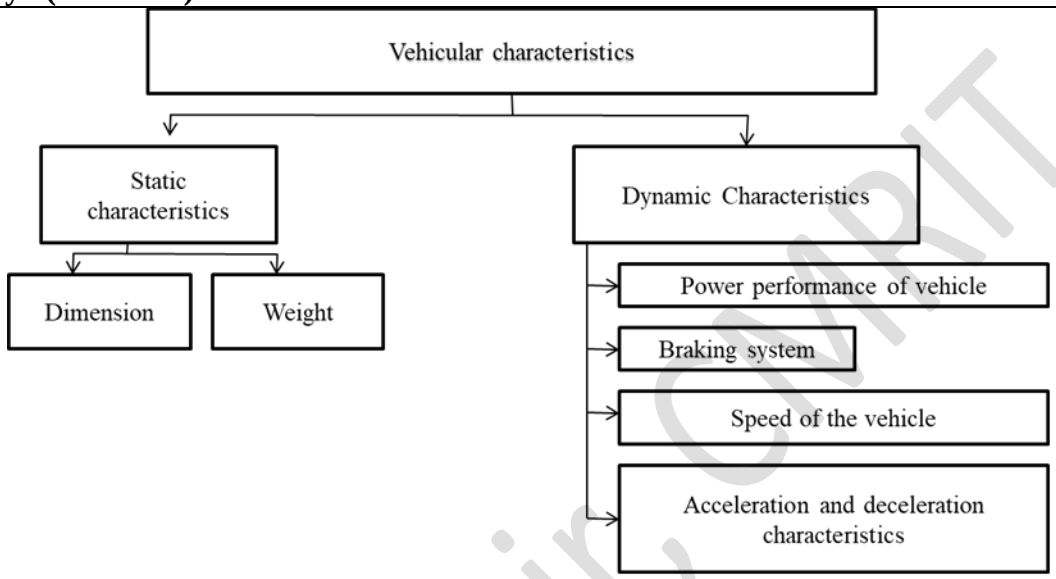
Speed-density

- Speed will be maximum, referred to as the free flow speed, and when the density is maximum, the speed will be zero.
- The most simple assumption is that this variation of speed with density is linear

Speed-flow

- The flow is zero either because there are no vehicles or there are too many vehicles so that they cannot move.

	➢ At maximum flow, the speed will be in between zero and free flow speed. ➢ The maximum flow qmax occurs at speed u ➢ It is possible to have two different speeds for a given flow.
2a	**What are the different vehicular characteristics which affect road design and explain briefly? (10 marks)**



Static characteristics influencing high way design include dimensions and weight. Their affects on high way design are provided in the following table

Dimensions	Affects on road design
Length of vehicle	Geometric design, capacity, overtaking distance and maneuver of vehicle, turning radius, parking facility, design of valley and dips
Width of vehicle	Width of traffic lanes, shoulders and parking, capacity, and traffic flow and traffic density.
Height of vehicle	Clearance of overhead structure, design of underpasses, height of barricades
Height of driver seat	Visibility distance
Height of headlight	Sight distance at valley curves
Weight	thickness of pavement, the vehicle weight is indirectly dependent upon the size of the vehicle and its turning radius

Dynamic characteristics are operational characteristics that involve the forces that cause the motion of vehicle. The different dynamic characteristics are

Power performance of vehicles

Braking system

Acceleration and deceleration characteristics

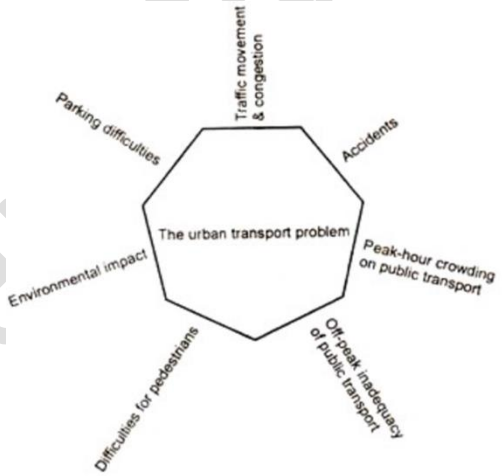
Speed of the vehicle

Power performance of vehicles: power developed by the engine should be sufficient to overcome all resistance to motion at the desired speed and to accelerate at any desired rate to the design speed. The various forces that are acting are

Rolling resistance

Air resistance

Grade resistance

	Inertia force during acceleration and deceleration Transmission losses **Braking system:** when brakes are applied, friction between road surface and tyre comes into play and the vehicles come to a stop. This depends upon the roughness of the surface and whether it is dry/wet. **Acceleration and deceleration characteristics:** maximum acceleration is achieved at low speeds. Cars have higher acceleration than commercial vehicles. Deceleration is caused when the engine is shut off and vehicle is allowed to coast and brakes are applied. This is dependent upon, the efficiency of brakes and coefficient of friction at the interface. **Speed of the vehicle**: this will influence, acceleration and braking characteristics, braking sight distance and different sight distances.
2b	**Discuss various urban traffic problem that India is facing. List some remedial measures also. '** **(10 Marks)**
	The seven facets of urban traffic problems can be represented as follows: This includes: 1. Traffic movement and congestion 2. Peak-hour crowding on public transport 3. Off-peak inadequacy of public transport 4. Difficulties for pedestrians 5. Parking difficulties 6. Accidents 7. Environmental impact  ***Traffic movement and congestion*** Traffic congestion occurs when urban transport networks are no longer capable of accommodating the volume of movements that use them. The location of congested areas is determined by the physical transport framework and by the patterns of urban land use and their associated trip-generating activities. Levels of traffic overloading vary in time, with a very well-marked peak during the daily journey-to-work periods. Causes of congestion include: ➢ Increased vehicle ownership ➢ Inadequancy of public transport ➢ Inadequacy of commercial vehicles ➢ Inadequacy in transport infrastructure To quantify congestion in a street, researchers have used congestion index. According to literature, congestion index is calculated as (1 – x/y), where x is the observed speed and y is the expected speed. The index ranges from 0 to 0.6 and a value of 0.25 is considered as average congestion index for Indian roads. ***Peak-hour crowding on public transport*** At peak hour, the following problems are observed ➢ Congestion inside the public transport ➢ Long queues at bus- stop/terminals ➢ Crowding at terminals and ticket offices ***Off-peak inadequacy of public transport*** India being a developing country, there is difficulty in employing operators during off-peak hours. However, if the fleet size is reduced, it will not cater to the peak hour demand as well. Hence, the most common way of cutting costs is by reducing off-peak services, but this in turn drives away remaining patronage and encourages further car use. However, in a country like India, rapidly growing urban populations with low car ownership levels provide sufficient off-peak demand to keep vehicle occupancy rates high throughout the day. ***Difficulties for pedestrians***

Pedestrians form the largest category of traffic accident victims. Problems faced the pedestrians include:

- Increased vehicular traffic volume
- Obstruction by parked cars
- Increasing pollution of the urban environment, with traffic noise and exhaust fumes affecting most directly those on feet.
- Problem of access to facilities and activities in the city.
- The replacement of small-scale and localised facilities such as shops and clinics by large-scale superstores and hospitals serving larger catchment areas has put many urban activities beyond the reach of the pedestrian. These greater distances between residences and needed facilities can only be covered by those with motorised transport.
- Lack of safe facilities is the biggest problem for the walker in developing countries

Parking difficulties

- Parking problem is the urban transport problem.
- Provision of adequate car parking space within or on the margins of central business districts (CBDs) for city workers and shoppers is a problem that has serious implications for land use planning.
- Proliferation of costly and visually intrusive multi-storey car-parks can only provide a partial solution
- On-street parking increases road congestion.

Accidents

- Increase in traffic volume and unplanned movement of traffic are the causes of accidents
- Increased speed and inappropriate geometric design are the causes of accidents

Environmental impact

- The operation of motor vehicles is a polluting activity.
- Traffic noise is the major environment problem caused by traffic in urban areas.
- The noise from motor vehicles comes from various sources. The engine, exhaust and tyres are the most important ones but with goods vehicles, additional noise can be given off by the body, brakes, loose fittings and aerodynamic noise.
- The level of noise is also influenced by the speed of the vehicle, the density of the traffic flow and the nature of the road surface on which the vehicle is operating.
- Traffic fumes, especially from poorly maintained diesel engines is more dangerous. The fumes, which are emitted, contain four main types of pollutant:

Carbon monoxide: This is a poisonous gas caused as a result of incomplete combustion;
Unburnt hydrocarbons: This caused by the evaporation of petrol and the discharge of only partially burnt hydrocarbons;
Other gases and deposits: Nitrogen oxides, tetra-ethyl lead and carbon dust particles;
Aldehydes: Hydrocarbon fumes are also emitted from the carburettor and petrol tanks, as well as from the exhaust system.

Sustainable solutions:

Transport planning and modelling

One of the reasons for unregulated urban growth and sprawl in India is the lack of integration of land-use and transportation planning. Traditional demand modelling techniques which adopt trip-based approach and uses 'trips' as the basic unit of analysis have limitations of dealing with behavioural issues, for instance, modelling multistop tours, etc.
Top-down approach should be resorted to wherein we start with a set of goals/ objectives.

Non-motorized transport

In Indian cities, CBD's are the most congested/polluted parts and NMT unfriendly because the private vehicles are allowed to enter a CBD and it is perceived as good for businesses located inside a CBD. Study on impact of NMT and/or PT zones on the overall mobility within and outside a CBD, and on the businesses in general.
Improve pedestrian facilities.

Public transport

An affordable, networked public transport with a desired minimum level of service would always attract ridership in Indian cities

Good integration of multi-modal mass transit systems to serve the overall mobility needs of the city. Inter- and intra-connectivity that utilizes public and private mode and develop an efficient transport system.

Driver behaviour and road safety

Introducing an effective and comprehensive driver licensing and testing programme all over the country

Effective and comprehensive driver education courses.

Traffic management

Leving parking charges in CBDs and other busy areas.

Develop a clear parking policy which would guide the fixation of tariffs and other restraints on vehicular parking.

Congestion pricing is another good instrument to control travel demand.

MODULE 2

3a **List out the objectives of traffic volume studies and origin destination studies. (10 Marks)**

Traffic volume studies

- Helps in understanding the efficiency at which system works at present
- Helps in estimating the quality of level of services at which the system works
- We can estimate if traffic is above or below capacity
- Helps in evaluating congestion (High congestion high operational costs)
- Helps to draw up schemes for improvement
- Helps in traffic forecasting , provided we know a reasonable traffic growth data based on past studies
- If the average flow and the length of highway are known, the annual vehicle miles of travel can be computed. This is used for accident studies.
- Pavement design requires traffic volume data
- Traffic regulatory and control measures are designed based on traffic flow data
- To evaluate financial viability of toll road traffic volume data are required
- No of people involved in travel is important for transport planning.

Origin Destination studies

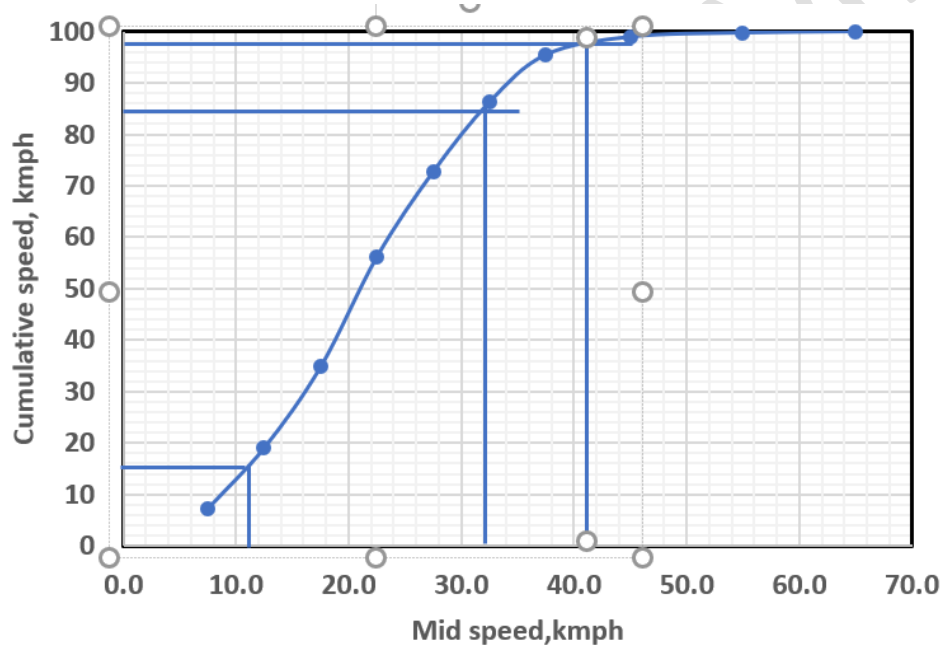
- To determine the amount of bypassable traffic that enters a town and thus establish the need of a bypass road
- To develop trip generation and trip distribution models in transport planning process
- To determine the extent to which the present highway system is adequate and plan new facilities
- To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

3b **Following data were obtained from spot speed studies. Determine**
(a) Upper and lower values of speed limit for regulation
(b) Design speed for checking the geometric design element of the highway.

Speed range (kmph)	Number of vehicles	Speed range (kmph)	Number of vehicles
5 to 10	230	30 to 35	430
10 to 15	375	35 to 40	290
15 to 20	500	40 to 50	110
20 to 25	680	50 to 60	25
25 to 30	525	60 to 70	8

Mid speed kmph	No of vehicles	Cumulative no of vehicles	Cumulative % vehicles
7.5	230	230	7.25

12.5	375	605	19.07
17.5	500	1105	34.83
22.5	680	1785	56.26
27.5	525	2310	72.80
32.5	430	2740	86.35
37.5	290	3030	95.49
45.0	110	3140	98.96
55.0	25	3165	99.75
65.0	8	3173	100.00
	3173		



i)Speed limit for regulation =V**85**=32kmph

(ii) Lower speed causing congestion = V15=11 kmph

(iii) Speed to check geometric deign elements = V98 = 41kmph

4a **Explain briefly speed and delay study by moving car method.**

Speed and flow can be obtained by travelling in a **car against and with flow,** and noting down the journey time, stopping time number of vehicles met with from opposite direction, and number of vehicles overtaking the test vehicle.

Even number of test cars are required with each carrying a driver and 3 observers.

One observer counts the opposite traffic

Another car observer details journey time, stopping/delays at different points enroute

3rd observer to record the details of overtaking/overtaken vehicles

The en route is divided into different sections 0.75 -1.5 km

Advantages:

- Gives an unbiased estimate flow
- It is economical
- Collects both speed and flow data

- Gives flow and speed for a section rather than a point
- Gives additional information on stops at intersection, delays, parked vehicles etc.

$$q_n = \frac{x_s + y_n}{t_s + t_n}$$

$\bar{t}_n = t_n - \frac{y_n}{q_n}$

Where,

q_n: Flow in the north bound direction

x_s: Opposing traffic count of vehicle met when the test car was travelling south

y_n: Number of vehicles overtaking the test car minus the number overtaken by the test car when the test car is travelling north

$\bar{t}_n$: Mean journey time in north bound direction (Use for finding journey and running speeds)

t_n: Journey time when the test vehicle travelling north direction

t_s Journey time when the test vehicle travelling south direction

Similarly, flow in south can be calculated

$$q_s = \frac{x_n + y_s}{t_s + t_n}$$

$\bar{t}_s = t_s - \frac{y_s}{q_s}$

Where,

q_s: Flow in the south bound direction

x_n: Opposing traffic count of vehicle met when the test car was travelling north

y_s: Number of vehicles overtaking the test car minus the number overtaken by the test car when the test car is travelling south

$\bar{t}_s$: Mean journey time in south bound direction (Use for finding journey and running speeds)

t_n: Journey time when the test vehicle travelling north direction

t_s Journey time when the test vehicle travelling south direction

4b **From the following data determine:**

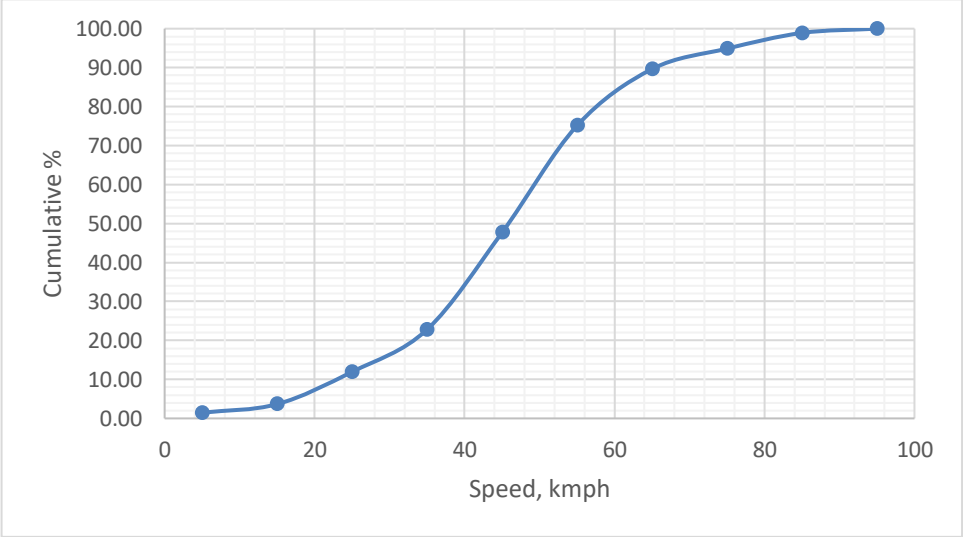
i) Speed limit values for mixed traffic

ii) Speed for geometric design

Speed /kmph)	Frequency	Speed /kmph)	Frequency
0 to 10	12	50 to 60	225
10 to 20	18	60 to 70	119
20 to 30	68	70 to 80	43
30 to 40	89	80 to 90	33
40 to 50	204	90 to 100	9

Speed /kmph)	Frequency	Mid speed	% vehicles	Cumulative %

0 to 10	12	5	1.46	1.46
10 to 20	18	15	2.20	3.66
20 to 30	68	25	8.29	11.95
30 to 40	89	35	10.85	22.80
40 to 50	204	45	24.88	47.68
50 to 60	225	55	27.44	75.12
60 to 70	119	65	14.51	89.63
70 to 80	43	75	5.24	94.88
80 to 90	33	85	4.02	98.90
90 to 100	9	95	1.10	100.00



i)Speed limit for regulation =V**85**=60 kmph

(ii) Lower speed causing congestion = V15=28 kmph

(iii) Speed to check geometric deign elements = V98 = 83kmph

MODULE 3

5a **Enumerate the design factors and advantages of rotary intersection.**

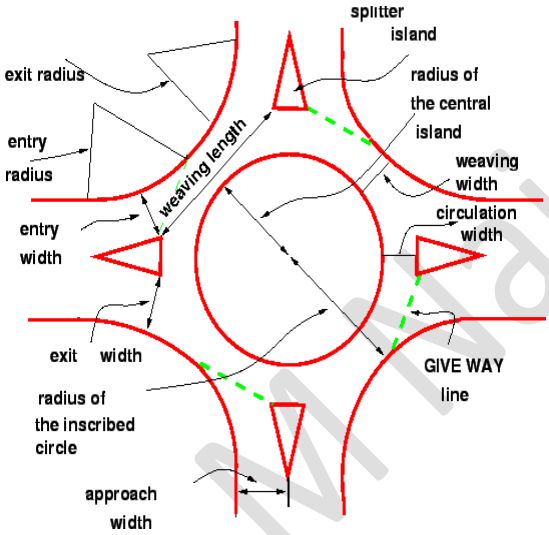
Advantages of rotary intersection

- 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, none of the vehicles need to be stopped, unlike in a signalized intersection.
- 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.

Guidelines for the selection of rotary intersection

- Rotaries are suitable when the traffic entering from all the four approaches are relatively equal.
- A total volume of about 3000 vehicles per hour can be considered as the upper limiting case and a volume of 500 vehicles per hour is the lower limit.
- A rotary is very beneficial when the proportion of the right-turn traffic is very high; typically if it is more than 30 percent.
- Rotaries are suitable when there are more than four approaches or if there is no separate lanes available for right-turn traffic.
- Rotaries are ideally suited if the intersection geometry is complex.

Rotary intersections or round about are special form of at-grade intersections laid out for the movement of traffic in one direction around a central traffic island. Traffic operations at rotary include diverging, merging and weaving.



There are 6 design elements of rotary intersection

1)Design speed

- The normal practice is to keep the design speed as **30 and 40 kmph** for urban and rural areas respectively.

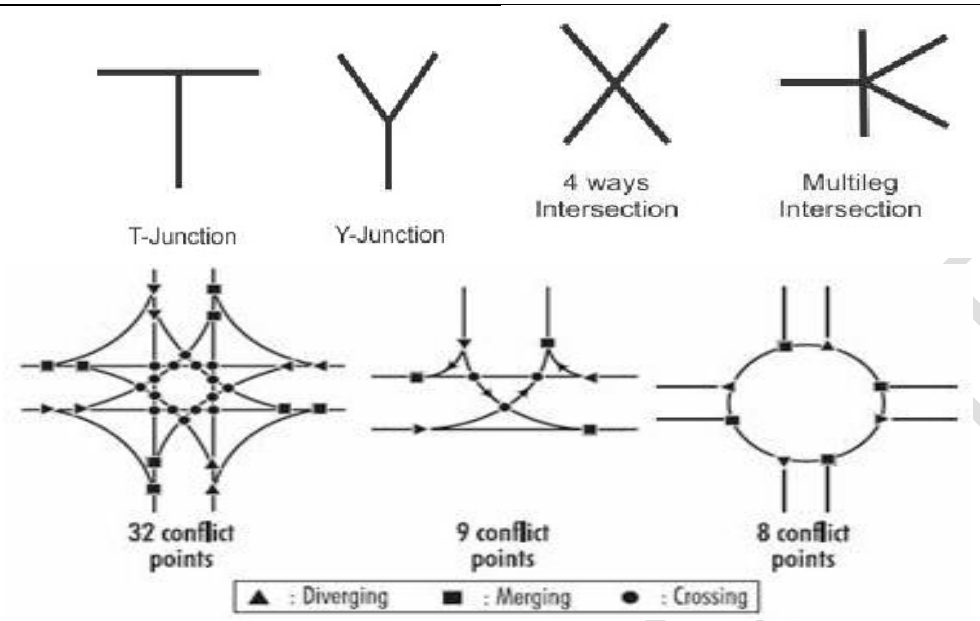
2)Entry, exit and island radius

- The radius at the entry depends on various factors like **design speed, super-elevation,** and **coefficient of friction.**
- The **entry radius** of about **20 and 25 meters** is ideal for an **urban and rural** design respectively.
- A general practice is to keep the **exit radius** as **1.5 to 2 times** the **entry radius**.
- The radius of the **central island** which is about **1.3 times that of the entry curve** is adequate for all practical purposes.

3)Entry and exit width:

- The width of the road at entry and exit will be **lower** than the width of the road at the approaches to enable reduction of speed.
- IRC suggests that a **two lane road of 7 m width should be kept as 7 m** for urban roads and **6.5 m for rural roads**.

	➢ Further, a three lane road of **10.5 m is to be reduced to 7 m** and **7.5 m** respectively for urban and rural roads. **4)Weaving width (w)** ➢ The width of the weaving section should be higher than the width at entry (e_1)and exit(e_2) $$W_{weaving} = \left(\frac{e_1 + e_2}{2}\right) + 3.5m$$. **5)Weaving length (l):** ➢ 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 speed **6) Capacity (Q_w)** The capacity of rotary is determined by the capacity of each weaving section by using the following empirical formula, where p is the proportion of weaving traffic. $$Q_w = \frac{280w[1 + \frac{e}{w}][1 - \frac{p}{3}]}{1 + \frac{w}{l}}$$
5b	**Write short notes on: i) At-grade intersection ii) Channelized intersection. (10 Marks)**
	An intersection is the area shared by the joining or crossing of two or more roads. Requirements for good intersection design ➢ Number of intersections should be minimum. ➢ Geometric layout should be such that hazardous movements are eliminated. ➢ Design should permit the driver to discern quickly from the layout or from the traffic signs, the path he should follow and the actions of merging and diverging. ➢ Conflicting points should be minimum. ➢ Traffic path should be smooth without abrupt and sharp corners. ➢ Crossing traffic should be given adequate waiting space.



Levels of intersection control

Passive control : there is no explicit control on the driver.

- ✓ No control
- ✓ Traffic signs
- ✓ Traffic signs plus marking

Semi control: some amount of control on the driver is there from the traffic agency.

- ✓ Channelization:
- ✓ Traffic rotaries

Active control: means the movement of the traffic is fully controlled by the traffic agency and the drivers cannot simply manoeuvre the intersection according to his choice.

- ✓ Traffic signals
- ✓ Grade separated intersections

Vehicles approaching an intersection are directed to definite paths by islands, marking etc. and this method of control is called channelization. (Fig. 1 and Fig. 2)

Advantages:

- ➢ Provides more safety and efficiency.
- ➢ Reduces the number of possible conflicts
- ➢ Reduces the area of conflicts available in the carriageway.
- ➢ The presence of traffic islands, markings etc. forces the driver to reduce the speed and becomes more cautious while manoeuvring the intersection.
- ➢ A channelizing island also serves as a refuge for pedestrians and makes pedestrian crossing safer.

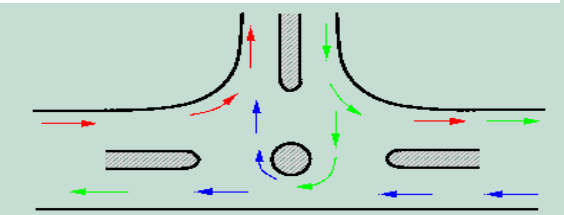


Figure 1: Channelization of traffic through a three-legged intersection

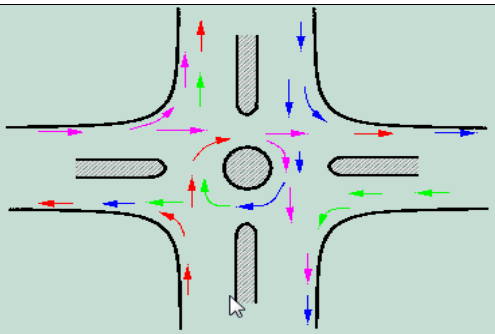


Figure 2: Channelization of traffic through a four-legged intersection

6a **What are the advantages and disadvantages of traffic signal? (10 Marks)**

Advantages of traffic signals

- Provide orderly movement of traffic at the intersection.
- The quality of traffic flow is improved by forming compact platoons of vehicles, provided all the vehicles move at approximately the same speed.
- Reduction in accidents due to crossing conflict, notably the right angled collisions.
- Traffic handling capacity is highest among the different types of intersections at-grade.
- Provide a chance to traffic of minor road to cross the continuous traffic flow of the main road at reasonable intervals of time.
- Pedestrians can cross the roads safely at the signalized intersection.
- When the signal system is properly co-ordinate, there is a reasonable speed along the major road traffic.
- Automatic traffic signal may work out to be more economical when compared to manual control.

Disadvantages of traffic signals

- The rear-end collisions may increase.
- Improper design and location of signals may lead to violations of the control system.
- Failure of the signal due to electric power failure or any other defect may cause confusion to the road users.
- The variation in vehicle arrivals on the approach roads may cause increase in waiting time on one of the roads and unused green signal time on other road, when fixed time traffic signals are used.
- Excessive delay of vehicle may be caused particularly during off-peak hours. • Drivers may be induced to use less adequate and less safe routes to avoid delays at signals.

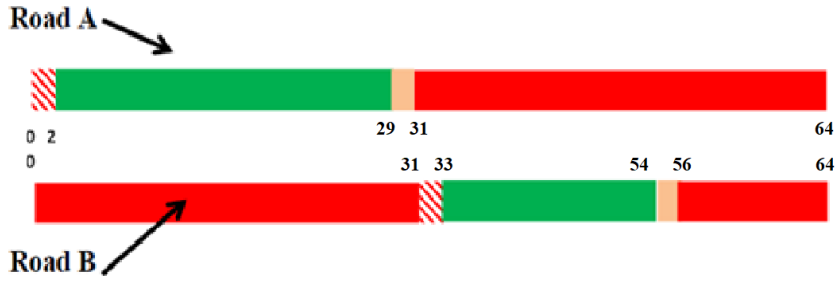
6b **The average normal flow of traffic on cross roads A and B during design period are 410 and 260 pcu per hour. The saturation flows are 1260 and 1000 pcu per hour respectively. The all red time required for pedestrian crossing is 12 seconds. Design a two phase traffic signal by Webster's method.**

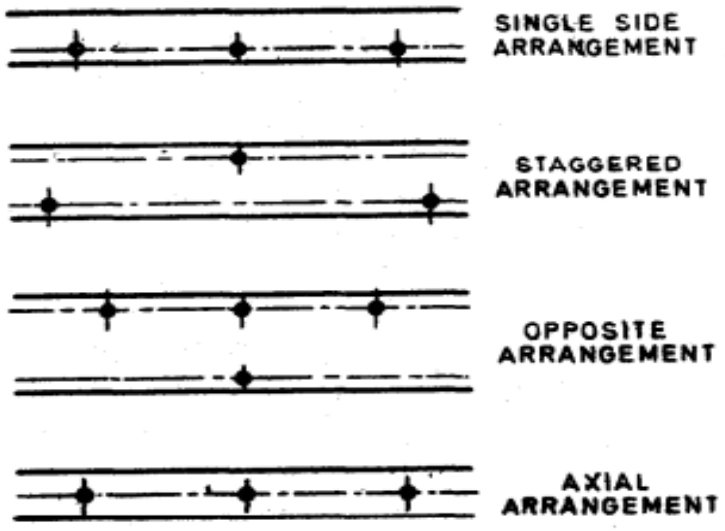
Assume time lost due to starting delays = 2 sec /phase

Total lost time = R+nl= 12+2×2= 16sec.

yA = 410/1260 = 0.33

yB = 260/1000 = 0.26

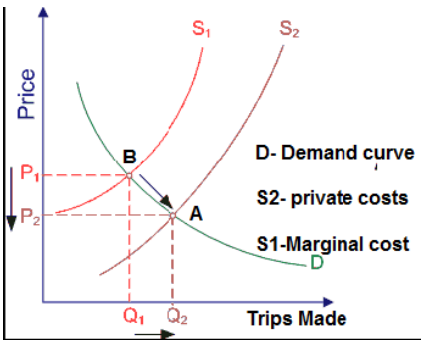
	y = 0.33+0.26 = 0.59 C0 = Optimum cycle time = $1.5L+5/(1-y)=1.5\times16+5/(1-0.59)$ = 64 sec. Effective green time = 64-16= 48 sec Effective green time for A = 0.33/0.59×48=27 sec Effective green time for B = 0.26/0.59×48=21 sec 
	MODULE 4
7a	**Briefly explain the various causes of accidents. (10 marks)**
	There are four basic elements in a traffic accident (i) The road users (ii) The vehicles (iii) The road and its condition (iv) Environmental factors The different factors can be enlisted as follows: (i) Drivers : excessive speed, carelssness, violation of rules and regulations, sleep, alcohol (ii) Pedestrians: violation of rules, carelessness (iii) Passengers : alighting or boarding the moving vehicles (iv) Vehicle effects – failure of brakes, steering system, lighting system, tyre bursts any any other defect in the vehicles (v) Road condition : slippery or skidding road surfaces, pot holes, ruts and other damaging conditions on the road surfaces (vi) Road design: defect in geometric design like inadequate sight distance, inadequate width of shoulders, improper kerb design, improper lighting and improper traffc control devices. (vii) Weather : unfavourale weather conditons like fog, mist, snow, dust, smoke or heavy rainfall and so on (viii) Animals : stray animals on the road (ix) Other causes : incorrect signs or signals, ribbon development, level crossing, advertisement boards and so on.
b	**Explain various design factors of highway lighting. (10 marks)**
	Design factors for highway lighting are • Lamps – the various types of lamps in use for highway lighting are filament, fluorescent lamps, sodium or mercury vapour lamps. • Luminaire distribution of light- the distribution of light should be downward so that high percentage of lamp light is utilized for illuminating the pavement and

	the adjacent areas. The distribution of luminaire should cover the pavement between the kerbs and provide adequate lighting the adjacent areas i.e., 3 m to 5 m beyond the pavement edges. According to Indian Standards Institution, an average level of illumination of 30 lux on important roads carrying fast traffic and 15 lux on main roads, the ratio of minimum to average illumination being 0.4 • Spacing of lighting units – large lamps with high mountings and wide spacings would be preferred from economy point of view. • Height and overhang of mounting – usually mounting height range from 6 m to 10 m. • Lateral placement – the street lights should not be too close to the pavement edge. For roads with raised kerbs, the pole should be at a distance of 0.3 m to 0.6 m from the edge of the kerb. • Lighting layouts – this can be either single sided, staggered or central.  Spacing (s) of street lamp can be computed as $$s = \frac{\textbf{Lamp lumen} \times \textbf{coeffecient of utilization} \times \textbf{Maintenance factor}}{\textbf{average flux} \times \textbf{width of the road}}$$
8a	**Explain the measure to control the traffic noise. (10 marks)**
	Noise pollution Noise is the unwanted sound. Noise in cities is the result of a number of activities such as road traffic, aircraft, railways and industrial and constructional works. *Effect of noise:* This can be classified into three (i) Subjective effects: this include disturbance, noisiness etc and is difficult to be measured. (ii) Behavioural effects: the noise can influence the behavior of people like sleeplessness, disturbance in studies, distraction in student's mind etc. (iii) Physiological effects: it can cause startle or fright phenomenon. Considerable exposure can even cause deafness *Generation of noise is by* (i) Various parts of the vehicle.

	(ii) Interaction between vehicle and road surface (iii) Noise dependent upon speed, flow and density of traffic. Vehicle noise are attributed to • Engine • Inlet • Exhaust • Propulsion and transmission including gears • Brakes and horns • Chasis • Body structure • Loads in the vehicle • Door slamming ***<u>Measures to reduce noise pollution:</u>*** (i) Change in the design of vehicles- in India, Motor vehicles Act has made provisions to frame rules to control te noise produced by motor cycles. (ii) Changes in tyre/ surface characteristics- smooth surfaces result in less noise. (iii) Elimination of noisier vehicles- old vehicles produce more sound. (iv) Modifications in traffic operations- rerouting commercial vehicles and buses from residential areas, providing by-pass to prevent high speed traffic from entering towns, ensure continuous and smooth and eliminate acceleration noise, prohibiting blow horns. **(v)** Designing streets, buildings and areas for producing less noise- narrow streets create noise conditions (canyon effect). Hence, streets should be wide to reduce noise pollution. Shrubs, trees and grass on the side of the road act as sound barriers.
b	**Explain briefly promotion of non-motorized transport. (10 marks)**
	NMT i.e. walk, cycle and cycle rickshaw are green modes of transport that belong to the low carbon path, do not consume energy or cause pollution, provide social equity and in addition provides employment. ***Initiatives towards improving non-motorized transport (NMT)*** ***1.*** *National Urban Renewal Mission (NURM)* of Central Government would give priority to the construction of cycle tracks and pedestrian paths in all cities. 2. *Formulation and implementation of specific "Area Plans" in congested urban areas* that propose appropriate mix of various modes of transport including exclusive zones for NMT. 3. *Central Government Initiatives like Atal Mission for Rejuvenation and Urban Transformation –AMRUT, Smart Cities Mission* 4. Construction of segregated rights of way for walk and cycles. 5. Segregation of vehicles moving at different speeds would enable full trips using NMT but also as a means of improving access to Public Transport stations.

	6. Creative facilities like shade giving landscaping, provision of drinking water and resting stations along bicycle corridors 7. The use of the central verge along many roads, along with innovatively designed road crossings. 8. Pedestrian and cycle facilities including crossing facilities at busy intersections should be well-maintained and kept free of encroachments.
	MODULE 5
9a	**Explain Intelligent transport system for traffic management**
	Intelligent Transportation Systems **(ITS)** is the application of computer, electronics, and communication technologies and management strategies in an integrated manner to provide traveler information to increase the safety and efficiency of the surface transportation systems. These systems involve vehicles, drivers, passengers, road operators, and managers all interacting with each other and the environment, and linking with the complex infrastructure systems to improve the safety and capacity of road systems. **ITS user services** Some of the user services offered by ITS are described as follows: 1. **Travel and traffic management** The main objective of this group of services is to use real time information on the status of the transportation system to improve its efficiency and productivity and to mitigate the adverse environmental impacts of the system. This includes pre-trip information, enroute information, route guidance, route matching and information, traveller service information etc. 2. **Public transportation operations** This group of service is concerned with improving the public transportation systems and encouraging their use. This includes services like real time public transit services and its maintainence, enroute information, 3. **Electronic payment:** This user service allows travellers to pay for transportation services with a common electronic payment medium for different transportation modes and functions. Toll collection, transit fare payment, and parking payment are linked through a multi-modal multi-use electronic system. With an integrated payment system a traveller driving on a toll road, using parking lot would be able to use the same electronic device to pay toll, parking price and the transit fare. 4. **Commercial vehicle operations:** The aim is to improve the efficiency and safety of commercial vehicle operations including freight mobility, automated road side safety inspection, etc. 5. **Advance vehicle control and safety systems:** This user service aims to improve the safety of the transportation system by supplementing drivers' abilities to maintain vigilance and control of the vehicle by enhancing the crash avoidance capabilities of vehicles. 6. **Emergency management:** This includes emergency notification and personal security on the occurrence of an accident as well as emergency vehicle management. 7. **Information management:** This service is aimed to provide the functionality needed to store and archive the huge amounts of data being collected on a continuous basis by different ITS technologies.

	8. **Maintenance and construction management:** This user service is aimed to provide the functionality needed for managing the fleets of maintenance vehicles, managing the roadway with regards to construction and maintenance and safe roadway operations. **ITS Architecture** The ITS Architecture provides a common framework for planning, defining, and integrating intelligent transportation systems. It specifies how the different ITS components would interact with each other to help solving transportation problems. **ITS Planning** ITS planning is to integrate ITS into the transportation planning process
b	**Discuss the details of Traffic Systems Mangement**
	Transportation systems management (TSM) involves virtually all aspects of traffic engineering in a focus on optimizing system capacity and operations. TSM action involves: **1. Traffic Management – this involves** • **Traffic Operations -** Intersection and roadway widening, One-way streets, Turn-lane installation, Turning-movement and land-use, New freeway lane using shoulders • **Traffic Control -** Local intersection signal improvement, Arterial signal system, Area signal system, Freeway diversion and advisory signing, Freeway surveillance and control • **Roadway Assignment-** Exclusive bus lane-arterial, restrictions, Take-a-lane, Add-a-lane, Bus-only street, Contraflow bus lane, Reversible lane systems, Freeway HOV bypass, Exclusive HOV lane-freeway, Take-a-lane, Add- a-lane • **Pedestrian and Bicycle -** Widen sidewalks, Pedestrian grade separation, Bikeways, Bike storage, Pedestrian control barriers **2. Transit management-** • **Transit Operations -** Bus route and schedule modifications, Express bus service, Bus traffic signal predemption, Bus terminals • **Simplified Fare Collection -** Marketing program, Maintenance improvements • **Transit Management -** Vehicle fleet improvements, Operations monitoring program • **Inter-Modal Coordination-** Park and ride facilities, Transfer improvements **3. Demand management** • **Paratransit-** Carpool matching programs, Vanpool programs, Taxi/group riding programs, Dial-a-ride • **Work schedule -** Elderly and handicapped service, Staggered work hours and flex-time, Four-dav week **4. Restrain measures** • **Parking Management-** Curb parking restrictions, Residential parking control,Off-street parking, restrictions, HOV preferential parking, Parking-rate changes • **Restricted Areas -** Area licensing, auto-restricted zones, Pedestrian malls, Residential traffic control • **Commercial Vehicle -** On-street loading zones, Off-street loading zones, Peak-hour on-street loading prohibition, Truck route system

	• **Pricing -** Peak-hour tolls, Low-occupancy vehicle tolls, Gasoline tax, Peaoff-peak transit fares, Elderly and handicapped fares, Reduced transit fares
10 a	**Write short notes on the following:** **Traffic Congestion** **Road Pricing System** **Travel Demand Management** **Traffic Regulatory Measures. (20 marks)**
	Traffic congestion occurs when urban transport networks are no longer capable of accommodating the volume of movements that use them. The location of congested areas is determined by the physical transport framework and by the patterns of urban land use and their associated trip-generating activities. Levels of traffic overloading vary in time, with a very well-marked peak during the daily journey-to-work periods. Causes of congestion include: ➢ Increased vehicle ownership ➢ Inadequancy of public transport ➢ Inadequacy of commercial vehicles ➢ Inadequacy in transport infrastructure To quantify congestion in a street, researchers have used congestion index. According to literature, congestion index is calculated as (1 – x/y), where x is the observed speed and y is the expected speed. The index ranges from 0 to 0.6 and a value of 0.25 is considered as average congestion index for Indian roads. **Road Pricing** This is a method of road user taxation, charging the users of congested roads according to the time spent or distance travelled on those. The principle behind road pricing is that those who cause congestion or use the road in the congested period should be charge, thus giving the road user the choice of whether to make a journey or not. Economic principles behind road pricing: Journey costs are made up of (i) Private journey costs comprising of vehicle operating costs, value of individual's travel time. (ii) Congestion cost representing the cost imposed by road users on each other in terms of external delay (iii) Environmental costs (iv) Road maintenance costs  The benefit the road user obtains from the journey is the price he is prepared to pay in order to make the journey. As the price gradually increases, a point will be reached when the trip-maker considers it as not worth performing the trip. This critical price would be his assessment of the benefit he/she derives from making the journey. At costs, less than critical price, he enjoys a net benefit called as Consumer surplus. Similarly the cost incurred in making the trip increases with the traffic volume which is called as private costs. On making any trip

each road user creates an additional cost (marginal cost) in terms of congestion, parking etc. All these costs are shown in the figure below. Shift from A to B indicates road pricing.

Travel Demand Management

TDM techniques are aimed at reducing the traffic flows, especially during the peak hour.

Direct methods are the methods that can be directly quantified/ visible by the road user itself. Indirect methods are the methods which cannot be directly measured. Among the different techniques enlisted below, except road pricing all are direct methods.

The different techniques adopted are

1. Car-pooling and other ride-sharing programmes- Leverage public and private funds to increase the use of ridesharing and other commuting options that reduce traffic congestion and improve air quality
2. Peripheral parking
3. Chartered buses - Subsidizing transit costs for employees or residents, workplace travel plans
4. Staggering of office hours - Flex-time work schedules with employers to reduce congestion at peak times
5. Internal shuttle service in CBD
6. Parking restraint - Requiring users of parking to pay the costs directly, as opposed to sharing the costs indirectly with others through increased rents and tax subsidies.
7. Road pricing- Time, distance and place (TDP) road pricing, where road users are charged based on when, where and how much they drive.
8. Congestion pricing during peak hours.
9. Entry fee
10. Priority for buses in traffic - Including and improving public transportation infrastructure, such as subway entrances, bus stops and routes.
11. Restrictions on entry of trucks during day-time.
12. Including or improving pedestrian-oriented design elements, such as short pedestrian crossings, wide sidewalks and street trees.
13. Bicycle-friendly facilities and environments, including secure bike storage areas and showers.
14. Providing traveler information tools, including intelligent transportation system improvements, mobile and social applications, wayfinding tools, and other methods for promoting alternatives to single occupancy vehicle (SOV) modes
15. Road space rationing or alternate-day travel by restricting travel based on license plate number, at certain times and places.
16. Roadspace reallocation, aiming to re-balance provision between private cars which often predominate due to high spatial allocations for roadside parking, and for sustainable modes.

Traffic Regulatory Measures:

Traffic regulations include the regulations imposed on drivers and road users, vehicles.

Regulations on vehicles

	1. Speed limits: this is generally controlled by the type and volume of traffic. This is also dependent upon Environment of roads, Traffic composition, Character of road, Casualty 2. Enforcement of speed limits – violators will be summoned or arrested or punished. For enforcement, radar speedometers are installed. 3. Establishment of speed zones 4. Vehicle registration for different states, different purposes are categories with reference to registration plate number. The order of age can also be identified with reference to the alphabets associated with the number plate. 5. Construction and equipment of vehicles: regulations in this category include brake and sterring system, length of the truck trailer unit if any, wheel loaf, wheel load, emission, use of horns, periodical testing and inspection of vehicles, prohibition on use of horns and so on. 6. Control of transport vehicles – regulations with reference to goods movement, competition among different modes and so on. 7. Insurance: mainly to cover the liability in respect of death or injury to persons or damage to any property ***Regulations concerning the driver*** 1. Licensing of the driver – given to an individual after he passes a test of competence. He should be able to portray his ability as a driver as well as his knowledge in different rules and regulations. 2. Requirements of physical fitness – night blindness, epilepsy, inadequate perception, heart diseases etc make a person unfit for driving 3. Age of drivers – in india, an individual should be of 18 years of age to get adriving license, whereas he should be of minimum of 20 years to get license to drive transport vehicles. 4. Disqualification and endorsement of licenses- habitual drinking, dangerous dribing, offences and penalties make a person unfit for driving.