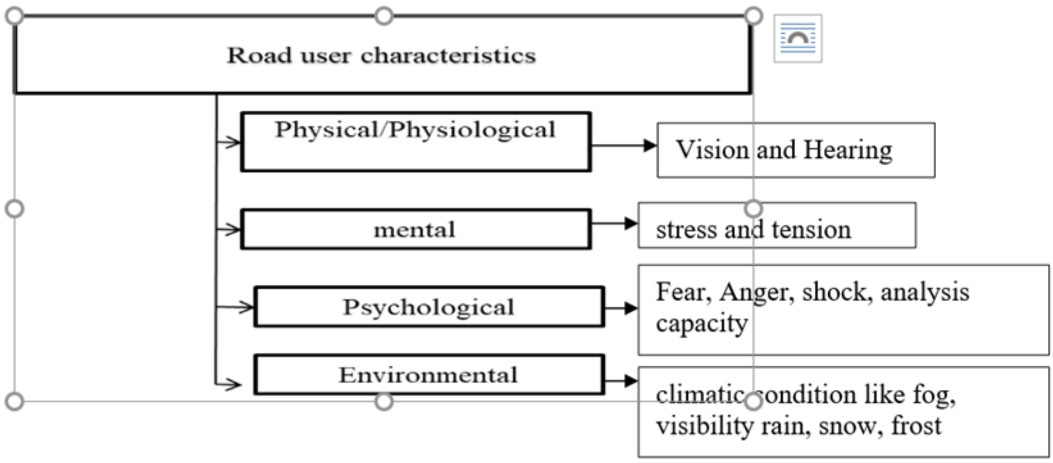
Internal Assessment Test 1- Solution – May 2021

Sub:	TRAFFIC ENGINEERING	Sub Code:	18CV652	Branch:	CSE/ISE/ME

1	Describe the different road user characteristics and with neat sketches explain PIEV theory and reaction time of a driver.	[07]



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.

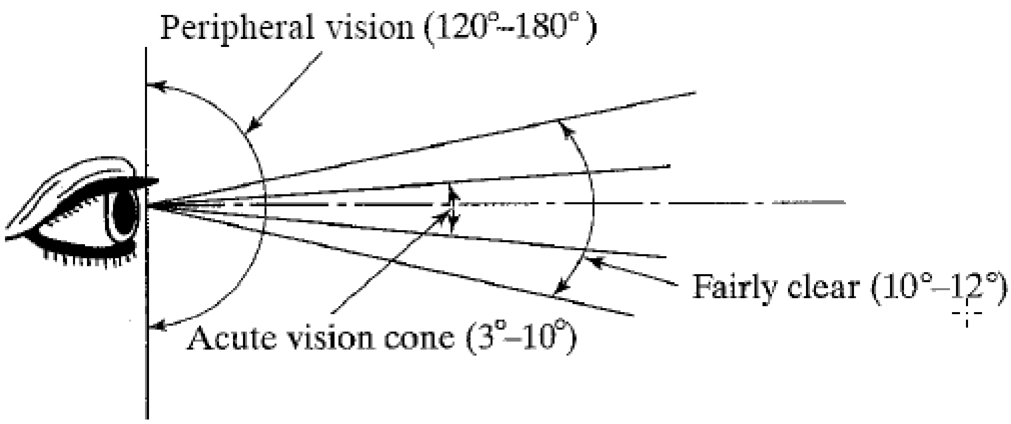
- ➢ Traffic signs are placed with in acute vision field
- ➢ Driver can see without changing his sight

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



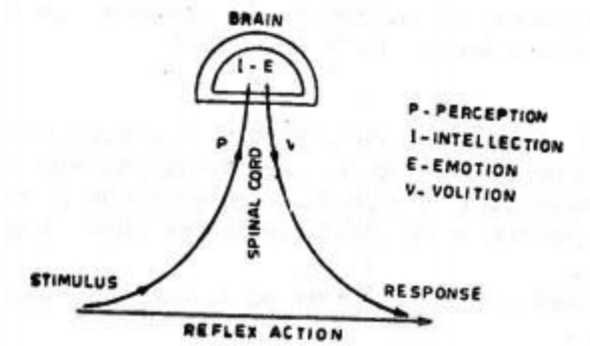
Hearing: Sound of nearing vehicles can alert the pedestrian. Elderly people with falling eye sight can better perceive through hearing.

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.

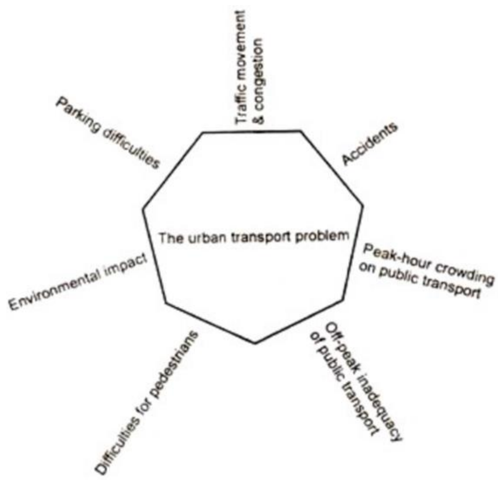


Reaction time of a driver is the time taken by a driver to respond to a situation and it is the sum of lag distance and brake distance. Lag distance is the distance travelled by the vehicle during the time taken by brain of a driver to understand a situation and brake distance is the distance travelled by the vehicle during the response time of the driver.

Scheme:
Different road user characteristics : 4
PIEV theory : 2
Reaction time of a driver : 1

2	Discuss different traffic engineering problems that India is facing. List some remedial measures also.	[08]

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. **Scheme:** 5 traffic problems - 5 3 sustainable solutions -3	
3	A passenger car weighing 3 tonnes is required to accelerate at a rate of 3m/s^2 in the first gear from a speed of 10 kmph to 25 kmph. The gradient is +1% and the road has a black topped surface. Frontal projection of the area of the car is 2 m^2. Car tyres have radius of 0.33 m. The rear axle gear ratio is 3.82:1 and the first gear ratio is 2.78:1. Calculate the engine horse power needed and the speed of the engine. Make suitable assumptions. Coefficient of air resistance =0.39, coefficient of rolling resistance =0.02. Tyre deformation factor = 0.95, transmission efficiency = 0.88.	[10]
	$m = 3000\ kg$ $a = 3\ m/s^2$ $i = 1.0$ $f = 0.02$ $A = 2\ m^2$ $C_a = 0.39$ $r_0 = 0.33\ m$ $\lambda = 0.95$ $G_t.G_a = 3.82 \times 2.78$ **η = 0.88** **V = 17.5 kmph = 4.86 m/s**	
	$Pf\ = mgf = 3000 \times 9.81 \times 0.02 = 588.6\ N$ $P_a = C_a A V^2 = 0.39 \times 2 \times 4.86 \times 4.86 =$ **18.42 N** $P_i = \frac{mig}{100} = \frac{3000 \times 1 \times 9.81}{100} = 294.3\ N$ $P_j = ma = 3000 \times 3 = 9000\ N$ $P_p = 588.6 + 18.42 + 294.3 + 9000 = 9901.32\ N$ **Power output =** $P_p.\ V = 9901.32 \times 4.86 = 48.12\ kW$ **Power output =** $\frac{48120}{735} = 65.47\ HP$ **Engine power = 65.47/0.88 = 74.4 HP** $V = \frac{2\ \pi r_w N}{60\ G_t G_a}$ $4.86 = \frac{2\ \pi \times 0.95 \times 0.33 \times N}{60\ \times 3.82 \times 2.78}$ **N = 1572 rpm** **Scheme:** Total resistance – 6 Engine power – 2 Engine speed - 2	
4	Distinguish the following: (a) Running speed and journey speed (b) Time headway and space headway Assume that you are traffic engineer with awareness of current state of art technology. In this context with which technology will you conduct speed and delay study for a stretch. Explain with relevant equations.	[07]

Running speed – is the average speed maintained by the vehicle over a given course while the vehicle is in motion

$$Running\ speed\ = \frac{Length\ of\ course}{Running\ time} = \frac{Length\ of\ course}{Journey\ time\ - Delay}$$

Journey speed – is the effective speed of vehicle of a vehicle between the two points.

$$Journey\ speed\ = \frac{Distance}{Total\ journey\ time\ (including\ delays)}$$

Headway= spacing (m)/Speed(m/s): Time headway or simply headway (h), is the time interval between the passage of the fronts of successive vehicles at a specified point. It is measured in seconds.

H_t = 1/volume

Minimum time head way = 1/ C (where C= capacity or maximum volume)

Space headway: Centre to centre distance between two successive vehicles measured from the same point on each vehicle

S = 1/ density

Unit : Km/vehicles or m/vehicles

Current state of art technology enables measurement of speed and delay studies via drones. Via drones images of road traffic can be collected. From this speed and delay can be captured. To calculate speed, two reference lines are considered and the

q – flow of vehicles in one direction of the stream

n_a – average no of vehicles counted in the direction of stream q, when the test vehicle travels in the opposite direction or against the stream

n_y - average no of vehicles overtaking the test vehicle minus the number of vehicles overtaken when the test vehicle is in the direction of the stream q

t_w - average journey time, when the test vehicle is traveling with the stream q

t_a - average journey time, when the test vehicle is running against the stream q

$$\boldsymbol{Average\ journey\ time,\ \bar{t} = t_w - \frac{n_y}{q}}$$

$$\boldsymbol{q = \frac{n_a + n_y}{t_a + t_w}}$$

Scheme:

Difference - 4

Explanation on state of art technology - 3

5 Describe the fundamentals of traffic flow with neat sketches. [08]

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.

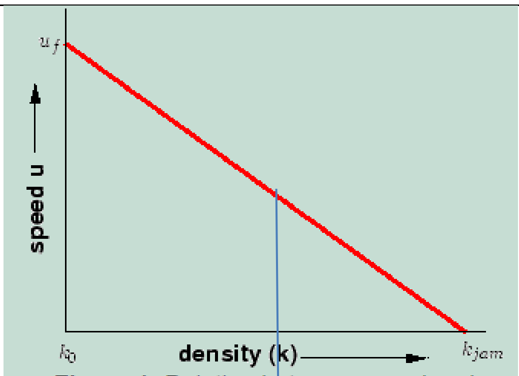


Figure 1: Relation between speed and density

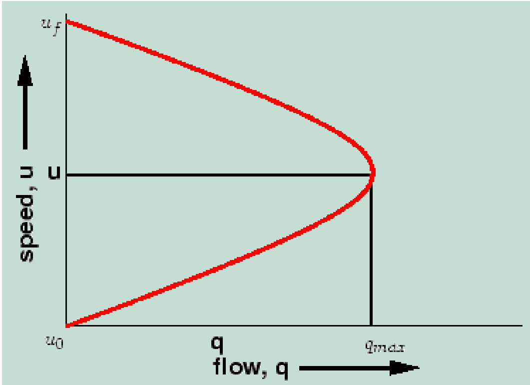


Figure 2: Relation between speed and flow

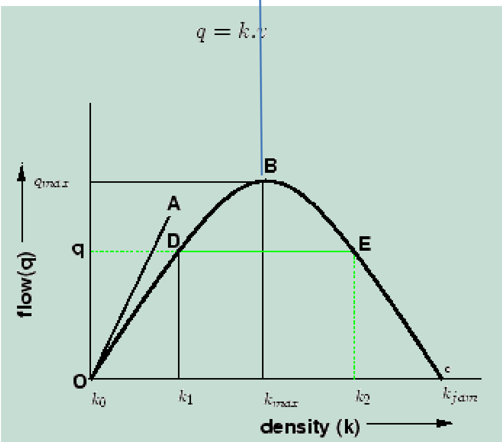


Figure 3: Relation between flow and density

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.

	Scheme: Diagrams and explanation – 3 + 3 + 2	
6	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.	[10]

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

Speed range (kmph)	Number of vehicles	Mid speed	% vehicles	Cumulative %
5 to 10	230	7.5	7.25	7.25
10 to 15	375	12.5	11.82	19.07
15 to 20	500	17.5	15.76	34.83
20 to 25	680	22.5	21.43	56.26
25 to 30	525	27.5	16.55	72.80
30 to 35	430	32.5	13.55	86.35
35 to 40	290	37.5	9.14	95.49
40 to 50	110	45	3.47	98.96
50 to 60	25	55	0.79	99.75
60 to 70	8	65	0.25	100.00

Upper speed limit = 32 kmph
Lower speed limit = 11 kmph
Design speed = 45 kmph

Scheme:
Table – 4
Graph – 3
Values - 3

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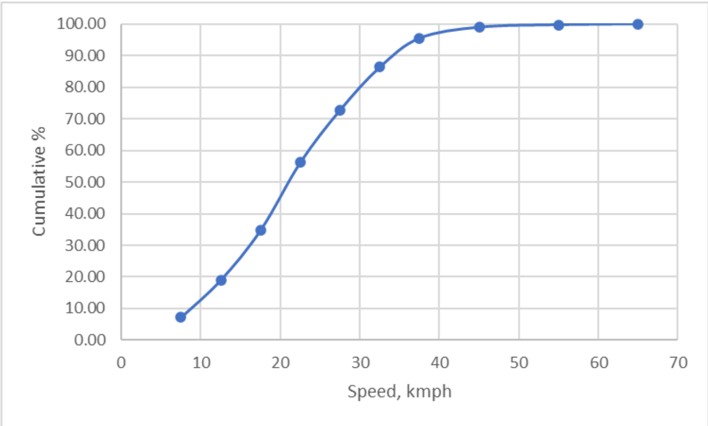

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