

- 1 (a) Outline the causes of accidents and suggest remedial measures for prevention
 (b) Explain with neat sketches different traffic signs. Give three examples under each category.
 (c) Write short notes on Rotary intersection its advantages and disadvantages. Draw a neat sketch and indicate various design elements of rotary 8+4+8

Ans:

(a) **The various causes of road accidents are:**

- **Road Users** - Excessive speed and rash driving, violation of traffic rules, failure to perceive traffic situation or sign or signal in adequate time, carelessness, fatigue, alcohol, sleep etc.
- **Vehicle** - Defects such as failure of brakes, steering system, tyre burst, lighting system .
- **Road Condition** - Skidding road surface, pot holes, ruts.
- **Road design** - Defective geometric design like inadequate sight distance, inadequate width of shoulders, improper curve design, improper traffic control devices and improper lighting,.
- **Environmental factors** -unfavorable weather conditions like mist, snow, smoke and heavy rainfall which restrict normal visibility and and makes driving unsafe.
- **Other causes** -improper location of advertisement boards, gate of level crossing not closed when required etc.

3 E's such as Engineering, Enforcement and Education can be utilized to reduce accidents.

Safety measures related to engineering

Road designs:

- Sight distances, width , horizontal and vertical alignment, intersection design elements
- Pavement surface characteristics, skid resistance values
- Necessary bypasses may be constructed
- Grade separated intersections

Preventive maintenance of vehicle

- braking system, steering system, lighting system should be checked regularly
- Heavy penalty on defective vehicles
- Special checks on public carriers

Before and after study

- By comparing the condition and collision diagnosis “before and after” the introduction of preventive measures
- After necessary improvements in design and enforcing regulation

Road lighting

- Proper road lighting especially at the intersections, bridge sites and at places where there are restriction in traffic movement

Safety measures related to enforcement

Speed control:

- Checks on spot speed of all vehicles should be done at different locations and timings and legal actions on those who violate the speed limit should be taken

Training and supervision

- The transport authorities should be strict while issuing licence to drivers of public service vehicles and taxis.
- Driving licence of the driver may be renewed after specified period, only after conducting some tests to check whether the driver is fit

Medical check

The drivers should be tested for vision and reaction time at prescribed intervals of time

Safety Measures related to education

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

Education of road users:

- The passengers and pedestrians should be taught the rules of the road, Correct manner of crossing etc.
- Introducing necessary instruction in the schools for the children and
- Posters exhibiting the serious results due to carelessness of road users.

Safety drive: Documentaries and films for road users and drivers

- Training courses and workshops
- Imposing traffic safety weeks

(b) **Mandatory Signs / Regulatory Signs**

- These signs are used to inform road users of certain laws and regulations to provide safety and free flow of traffic.
- These include all signs which give notice of special obligation, prohibition or restrictions with which the road user must comply.
- The violation of these signs is a legal offence.



Figure: Stop sign, give way sign, signs for no entry, sign indicating prohibition for right turn, vehicle width limit sign, speed limit sign

Cautionary Signs

These are used to warn the road users of certain hazardous conditions that exist on or adjacent to the roadway. They are in the shape of an equilateral triangle with its apex pointing upwards. They have a white background, red border and black symbols

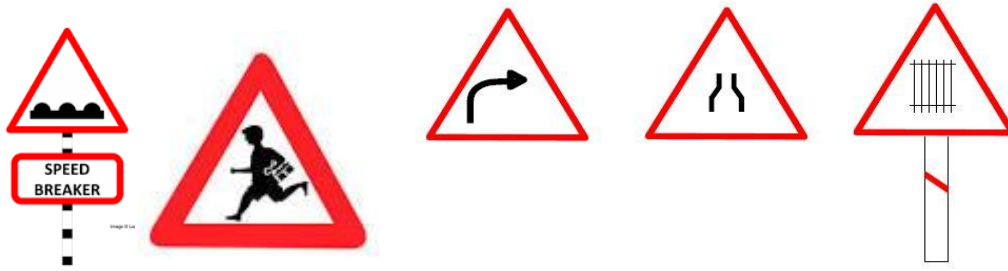
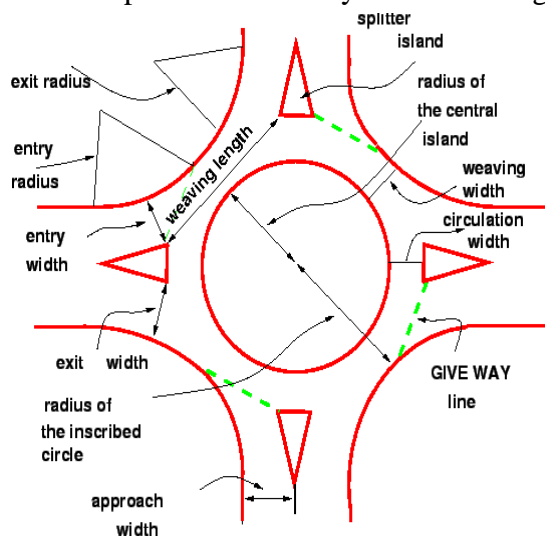


Figure: speed breaker, school, Right hand curve sign board, signs for narrow road, sign indicating railway track ahead)

Informatory Signs: These signs provide information to the driver about the facilities available ahead, and the route and distance to reach the specific destinations



(c) 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)

$$W_{\text{weaving}} = \left(\frac{e_1 + e_2}{2} \right) + 3.5m$$

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.

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

- 2 (a) Write short notes on Condition diagram and collision diagram
- (b) Explain i) At grade and grade separated intersections with neat sketches
- (c) Describe Fundamental flow diagram 4+4+7

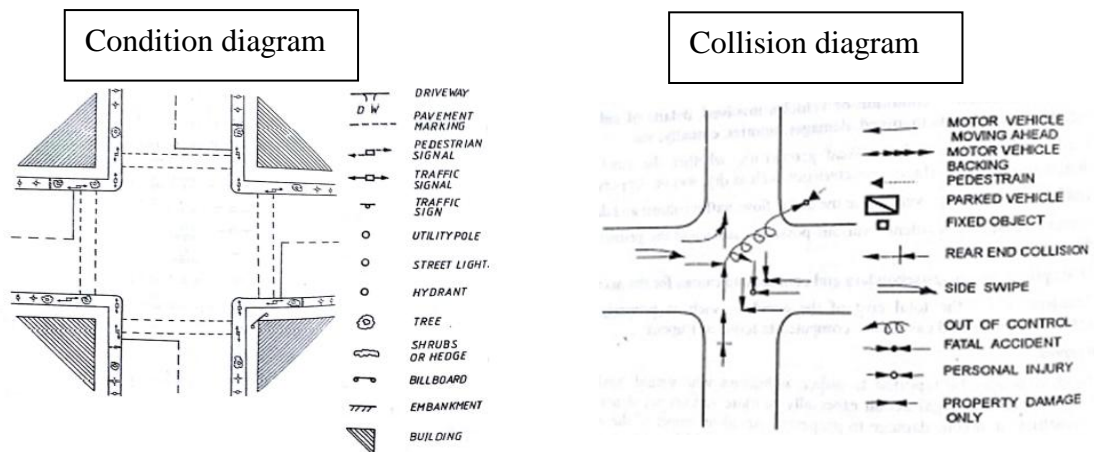
Ans:

(a) Condition Diagram:

- This is a diagram of the accident location drawn to scale.
- It shows important features of the road and adjoining area using standard symbols.
- Important features include width of roadway, shoulders, median, curves, kerb lines, bridges, culverts, trees, electric post, traffic signs and signals

Collision diagram:

- Depict the details of accident location, but not to scale using standard symbols.
- Show the approximate path of the vehicles and pedestrians involved in the accident.
- Collision diagram helps in comparing the accident pattern before and after remedial measures have been taken.



(b)

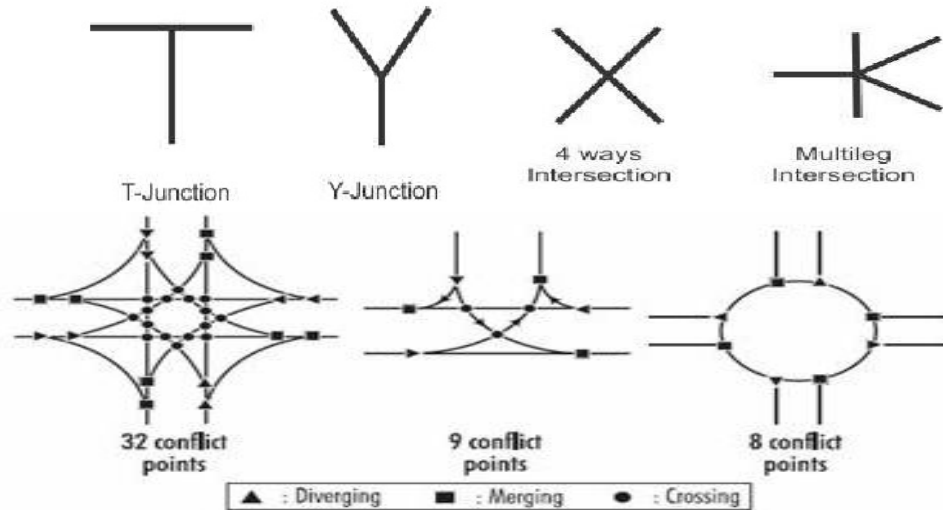
At-Grade Intersection

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.



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Grade separated intersections:

- Grade-separated intersections are provided to separate the traffic in the vertical grade.
- Different types of grade-separators are flyovers and interchange.

Flyovers itself are subdivided into overpass and underpass.

Grade separated intersections

- Interchange is a system where traffic between two or more roadways flows at different levels in the grade separated junctions.
- Trumpet interchange is a three leg interchange. If one of the legs of the interchange meets a highway at some angle but does not cross it, then the interchange is called trumpet interchange.

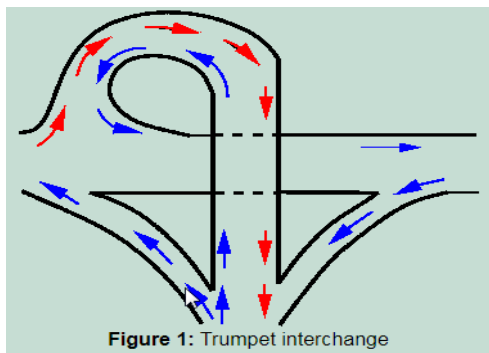


Figure 1: Trumpet interchange

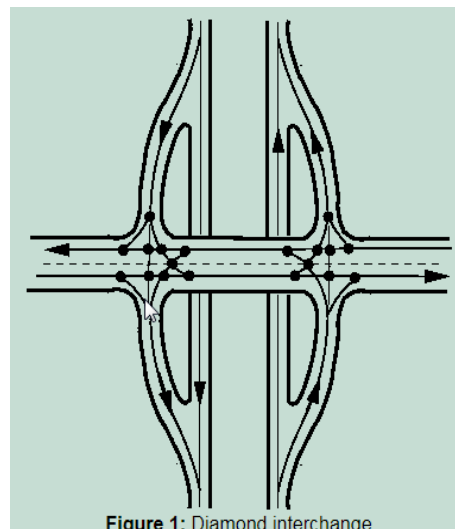


Figure 1: Diamond interchange

- Diamond interchange: Diamond interchange is a popular form of four-leg interchange found in the urban locations where major and minor roads crosses.
- Clover leaf interchange: It is a four leg interchange used when two highways of high volume and speed intersect each other with considerable turning movements. The main advantage of cloverleaf intersection is that it provides complete separation of traffic. In addition, high speed at intersections can be achieved. However, the disadvantage is that large area of land is required. Therefore, cloverleaf interchanges are provided mainly in rural areas.
- Partial Clover leaf interchange:

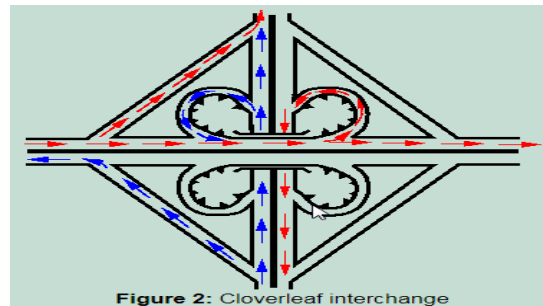
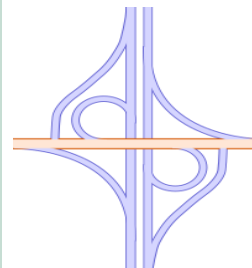


Figure 2: Cloverleaf interchange



Partial Clover leaf

(c)

Fundamentals 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 1

The equation for this relationship is shown below.

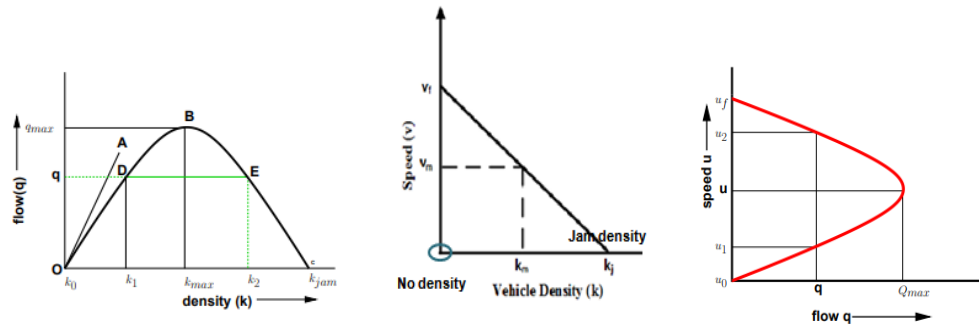
$$v = v_f - \left[\frac{v_f}{k_j} \right] .k$$

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. Similarly when the flow is less, density will be very less. As flow increases, traffic density decreases and speed decreases. When the vehicles are in jam condition also flow will be zero.

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 q_{max} occurs at speed u
- It is possible to have two different speeds for a given flow.

- 3 (a) Write a short note on road markings
- (b) Write a short note on traffic forecasting.
- (c) Mention various applications of “O and D” study. What are the different methods of presenting O-D data. 4+4+7

Ans:

(a) Road markings are defined as lines, patterns, words or other devices, except signs, set into applied or attached to the carriageway or kerbs or to objects within or adjacent to the carriageway, for controlling, warning, guiding and informing the users.

The road markings are classified as

- Longitudinal markings
- Transverse markings
- Object markings
- Word messages

Longitudinal markings

- Broken lines are permissive in character and allows crossing with discretion, if traffic situation permits.
- Solid lines are restrictive in character and does not allow crossing except for entry or exit from a side road or premises or to avoid a stationary obstruction.
- Double solid lines indicate severity in restrictions and should not be crossed except in case of emergency.

They are of the following types

- Centre-line marking
- Traffic lane lines
- No passing zones
- Warning lines
- Edge lines

Centre line:

- Centre line separates the opposing streams of traffic and facilitates their movements.
- Usually no centre line is provided for roads having width less than 5 m and for roads having more than four lanes.

Traffic lane lines

- The subdivision of wide carriageways into separate lanes on either side of the carriage way helps the driver to go straight and also curbs the meandering tendency of the driver.

No passing zones

- No passing zones are established on summit curves, horizontal curves, and on two lane and three lane where overtaking maneuvers are prohibited because of low sight distance.

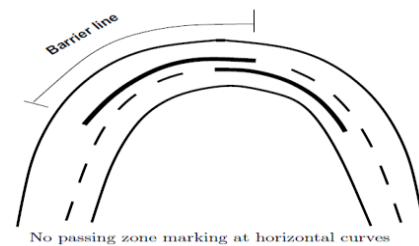
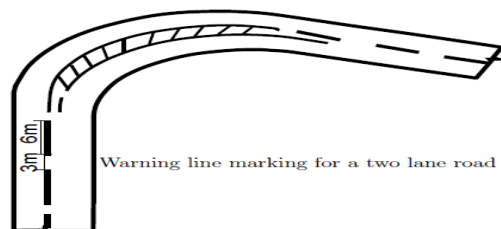
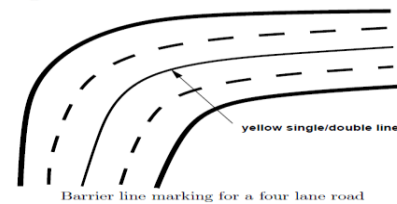
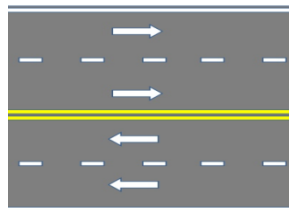
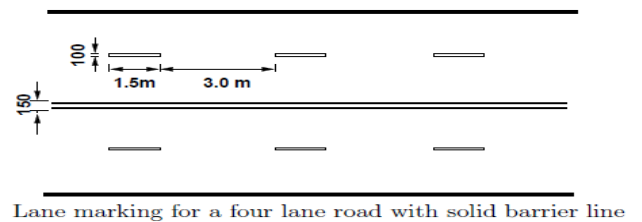
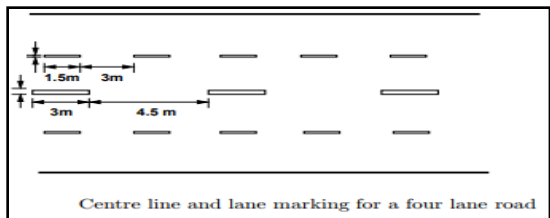
- It may be marked by a solid yellow line along the centre or a double yellow line.

Warning lines

- Warning lines warn the drivers about the obstruction approaches.
- They are marked on horizontal and vertical curves where the visibility is greater than prohibitory criteria specified for no overtaking zones.
- They are broken lines with 6 m length and 3 m gap.

Edge lines

- Edge lines indicate edges of rural roads which have no kerbs to delineate the limits upto which the driver can safely venture.
- They should be at least 150 mm from the actual edge of the pavement.
- They are painted in yellow or white.



Transverse markings

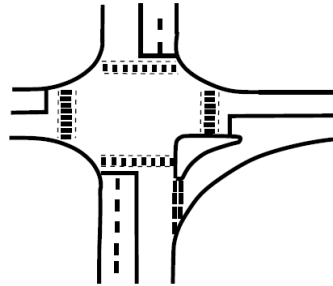
Stop line:

- Stop line indicates the position beyond which the vehicles should not proceed when required to stop by control devices like signals or by traffic police.

- They should be placed either parallel to the intersecting roadway or at right angles to the direction of approaching vehicles.

Pedestrian crossings

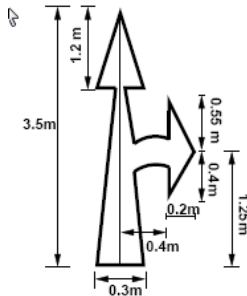
- Pedestrian crossings are provided at places where the conflict between vehicular and pedestrian traffic is severe.
- At intersections, the pedestrian crossings should be preceded by a stop line at a distance of 2 to 3m for unsignalized intersections and at a distance of one meter for signalized intersections.



Pedestrian marking near an intersection

Directional arrows

- Directional arrows should be used to guide the drivers in advance over the correct lane to be taken while approaching busy intersections.
- Because of the low angle at which the markings are viewed by the drivers, the arrows should be elongated in the direction of traffic for adequate visibility.



Object markings

Objects within the carriage way:

The obstructions within the carriageway such as traffic islands, raised medians, etc. may be marked by not less than five alternate black and yellow stripes.

The stripes should slope forward at an angle of 45° with respect to the direction of traffic..

Objects adjacent to carriageway

Objects adjacent to the carriageway like subway piers and abutments, culvert head walls etc. should be marked with alternate black and white stripes at a forward angle of 45° with respect to the direction of traffic.

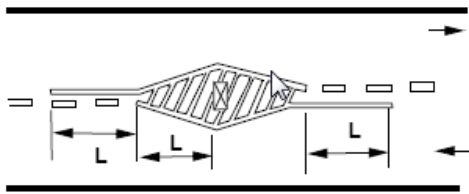
Word messages

Parking:

- The marking of the parking space limits on urban roads promotes more efficient use of the parking spaces and tends to prevent encroachment on places like bus stops, fire hydrant zones etc. where parking is undesirable.
- Such parking space limitations should be indicated with markings that are solid white lines 100 mm wide.

Hazardous location

- Wherever there is a change in the width of the road, or any hazardous location in the road, the driver should be warned about this situation with the help of suitable road markings.



(b) **Need for traffic forecast:** Scarcity of capital, to meet the traffic demand

Factors influencing traffic forecast

1. Population Growth/Migration
2. Land Use Changes
3. National/Regional Economy
4. Vehicle Operating Costs
5. Capacity Restraints
6. Induced Traffic due to new road facilities nearby
7. Vehicle ownership levels
8. Availability of alternative transport modes

Data for traffic prediction

Time series data consist of data that are collected, recorded, or observed over successive increments of time.

Cross-sectional data are observations collected at a single point in time.

Panel data are cross-sectional measurements that are repeated over time, such as yearly passengers carried for a sample of airlines.

Traffic forecast - Models

Linear trend

$$Y_t = \beta_0 + \beta_1 t + \varepsilon$$

Exponential Trend

$$Y = a(1+b)^T \quad \text{or} \quad \ln(Y) = \ln(a) + T \times \ln(1+b)$$

Polynomial Trend Analysis

$$Y = a + bT + cT^2$$

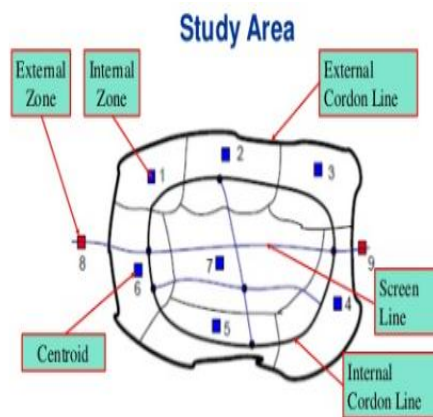
Forecasts based on Past Trends and Extrapolation – this can be done based on experience.

(c) The following objectives are identified for O-D studies:

1. To judge the adequacy of existing routes and to plan new network of roads.
2. To establish design standards for the road, bridges and culverts along the route
3. To locate expressways or major routes along the desire lines.
4. To establish preferential routes for various categories of vehicle including by-pass.
5. To locate new bridges as per traffic demands
6. To plan transportation system and mass transit facilities in cities including routes and schedules of operation.
7. To locate terminals and to plan terminal facilities.
8. To locate intermediate stops of public transport.

Road side interview method of collecting “O and D” data.

- i. Carried out on a screen line or cordon line
- ii. By **directly interviewing** the drivers at selected survey points or by issuing prepaid **post cards** containing the questionnaire to all or a sample of drivers
 - a. For small areas with population <5000, single circular cordon, at periphery of the town will be sufficient
 - b. For areas with population 5000-75000, two cordon lines, external cordon at the edge of urban development and internal cordon at the limits of CBD
- iii. The survey details can be used to check the accuracy of interview survey data
- iv. If traffic is light, for dual carriage way, one direction road side interview will be sufficient. For heavy traffic two way sampling is also required
- v. Necessitates suitable warning signs for the driver to alert the survey
- vi. So that the interview will reduce interruption traffic



Cordon and Screen lines

- 4 (a) Discuss the various types of parking, their advantages and disadvantages
- (b) Write short notes on
 i) Level of service iv) Desire line diagram
- (c) A vehicle of 2000 kg skids a distance of 36 m before colliding with a stationary vehicle of 1500 kg weight. After collision both vehicle skid a distance of 14 m. Assuming coefficient of friction 0.5, determine the initial speed of the vehicle. (i) after collision (ii) at collision (iii) before collision. 4+4+7

Ans:

(a) There are majorly two types of parking on street and off street parking.

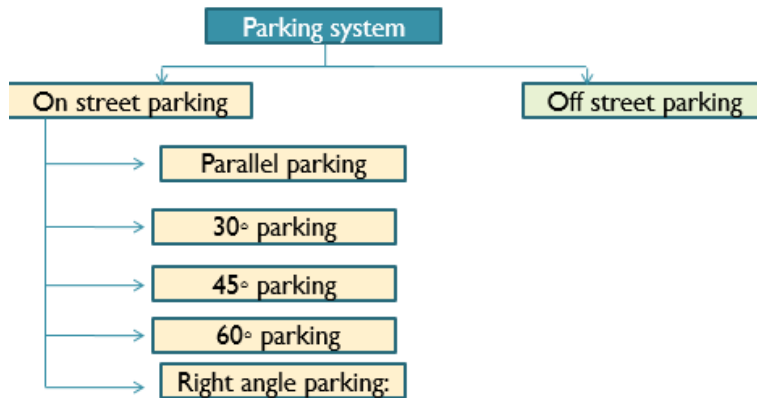
On street parking means the vehicles are parked on the sides of the street itself.

This will be usually controlled by government agencies

Common types of on-street parking are as listed above.

This classification is based on the angle in which the vehicles are parked with respect to the road alignment.

As per IRC the standard dimensions of a car is taken as 5×2.5 meters and that for a truck is 3.75×7.5 meters.



Parallel parking:

The vehicles are parked along the length of the road.

Advantages:

Here there is no backward movement involved while parking or un parking the vehicle.

Hence, it is the safest parking from the accident perspective.

This method of parking produces least obstruction to the on-going traffic on the road since least road width is used.

Disadvantages:

It consumes the maximum kerb length and therefore only a minimum number of vehicles can be parked for a given kerb length.

30° parking:

Advantages

- Easy parking
- less width requirements for layout

Disadvantages

- Requires the most pavement per vehicle
- Doesn't work well with two-way aisles

45° parking:

Advantages

- less width requirements for layout
- Easy maneuvering in and out of parking spaces
- Good visibility to the rear

Disadvantages

- Doesn't work well with two-way aisles
- Requires more pavement per vehicle than perpendicular parking configuration

60° parking

Advantages

- Easy maneuvering in and out of parking spaces
- Good visibility
- Lends itself to either one- or two-way aisles
- Most common short term parking configuration

Disadvantages

- Requires more pavement per vehicle than perpendicular configuration
- Handles less vehicles per linear meter

Right angle parking:

Advantages

- Works well with either one- or two-way aisles
- Handles the most vehicles per square meter of pavement
- Handles most vehicles per linear meter

Disadvantages

- Requires widest area
- Difficult maneuvering for some drivers
- Two-way traffic can create some visibility problems

Off street parking:

➤ *Surface car parks:*

They are located in a vacant piece of land surrounding an official complex or supermarket.

If there is a fee collecting mechanism, arrangements should be made for the same.

➤ *Multi storey car parks*

Normally designed for a capacity of 400-500 cars.

Ventilation should be provided

Gradient of the ramp: 1 in 10

Inside radius – 7m

Width : 3.75 m

➤ *Roof parks:*

Can be done using access ramps or lifts

Great care is required for the design of structural elements

➤ *Mechanical car parks*

Here a mechanical lift is provided to lift the car such that a parking lot can be used by more than one vehicle.

➤ *Underground parks*

Least influence on aesthetics

Proper ventilation and drainage is a must.

Generally provided in the basement of multi-storeyed buildings or malls

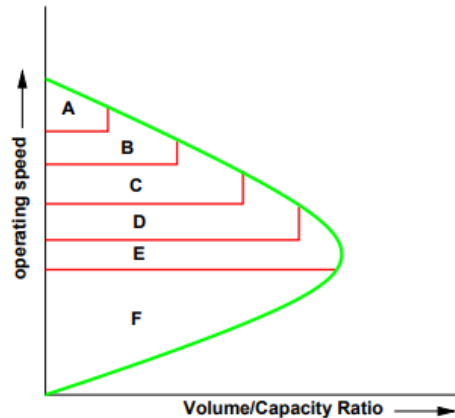
(b) **Level of service** This is defined as a quality measure describing operational conditions within a traffic stream, generally in terms of such service measures as speed and travel time, freedom to maneuver, traffic interruptions, and comfort and convenience. Six LOS are defined for each type of facility

LOS are designated using letter A to F

LOS A represents best operating conditions and LOS F is the worst

Each LOS represents a range of operating conditions and the driver's perception of those conditions.

Safety is not included in the measures to establish LOS



Space headway:

Centre to centre distance between two successive vehicles

$$S = 1/\text{density}$$

Unit : Km/vehicles or m/vehicles

Time headway:

Headway= spacing (m)/Speed(m/s)

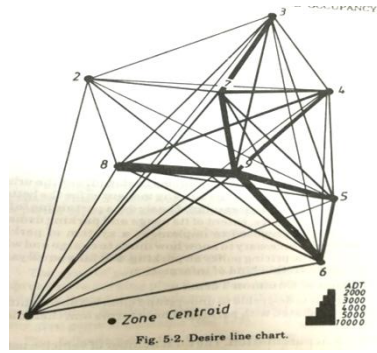
Time headway or simply headway (h), is the time interval between the passage of the fronts of successive vehicles at a specified point. It is measured in seconds.

$$H_t = 1/\text{volume}$$

$$\text{Minimum time head way} = 1/C \text{ (where } C = \text{ capacity or maximum volume)}$$

Desire lines:

- **Graphical representation** of O and D survey data.
- Desire lines are straight lines **connecting** the **origin** with **destination**, summarized in different zones.
- **Width** of the desire lines is drawn proportional to the **no of trips in both directions**.
- This map expresses the **actual desire** of road users and helps the planners to fine the **necessity** of a new link or **diversion/bridge**.
- They can be even completed with the existing flow pattern



(c)

After collision speed = 11.71m/s

At collision speed = 20.5m/s

Before collision speed = 27.8m/s

