

Road Traffic Engineering (315318)

Model Question Paper — Set B · Model Answers

Q.1**a) Four objectives of traffic engineering.**

2 M

1. To achieve safe movement of traffic — reduce road accidents.
2. To achieve rapid (fast) and efficient movement of people and goods with minimum delay and congestion.
3. To provide comfortable and convenient travel for all road users (drivers, pedestrians, cyclists).
4. To make economical use of the existing road capacity (maximum utilisation of road space).

*(Any four, ½ M each)***b) PIEV time; IRC value.**

2 M

PIEV time is the total reaction time of a driver from the instant an object is seen to the instant the brakes are applied — the sum of Perception, Intellection, Emotion and Volition times.

IRC adopts a total reaction time of **2.5 seconds** for calculating stopping sight distance.

*(Definition 1 M, value 1 M)***c) Necessities of O-D study.**

2 M

1. To plan a new road network and decide the most suitable routes (desire lines) of travel.
2. To decide whether existing roads are adequate or need improvement.
3. To plan bypasses, ring roads and expressways (to separate through traffic from local traffic).
4. To locate terminals, parking facilities, bus stops and bus routes.

*(Any four, ½ M each)***d) ITS definition; two applications in India.**

2 M

Intelligent Transportation System (ITS) is the application of advanced information, communication, sensor, electronics and computer technologies to roads and vehicles, in order to improve the **safety, efficiency, mobility and environmental performance** of the transportation system.

Applications in India: FASTag electronic toll collection on national highways; adaptive traffic signals / ITMS with e-challan cameras in cities; GPS bus tracking.

*(Definition 1 M, two applications 1 M)***e) Common terms in parking survey.**

2 M

1. **Parking accumulation**
2. **Parking volume**
3. **Parking load**
4. **Average parking duration**
5. **Parking turnover**

6. Parking index (occupancy)

(Any four, $\frac{1}{2}$ M each)

f) Define arboriculture.

2 M

Arboriculture is the science and art of planting, cultivating, protecting, maintaining and managing trees, shrubs and other woody plants — here, the systematic plantation and care of trees along roads.

(Definition 2 M)

g) Road-user causes of accidents.

2 M

1. Over-speeding and rash driving / wrong overtaking.
2. Drunken driving and driving under fatigue or sleep.
3. Use of mobile phone and distraction while driving.
4. Violation of rules — signal jumping, wrong-side driving, not using helmet / seat belt.
5. Careless crossing of road by pedestrians.

(Any four, $\frac{1}{2}$ M each)

Q.2

a) Difficulties in urban traffic and measures.

4 M

Difficulties:

- Rapid growth of number of vehicles compared to road space; narrow roads in old city areas.
- Mixed traffic — slow and fast vehicles, pedestrians and animals on the same carriageway.
- Encroachment by hawkers and shops; on-street parking reducing the effective width.
- Too many intersections close together, poor signal coordination.
- Inadequate public transport — more private vehicles.

Measures:

- Improve and encourage public transport (bus, metro), park-and-ride.
- Traffic regulation — one-way streets, turning restrictions, tidal-flow lanes, restriction of heavy vehicles during peak hours.
- Parking control — remove on-street parking from busy roads, provide off-street (multi-storey) parking, parking fees.
- Signal coordination and ITS based area traffic control.
- Road widening, grade-separated intersections, flyovers, bypasses and ring roads.

(Difficulties 2 M, measures 2 M)

b) In-out parking survey — accumulation, load, turnover, index.

4 M

Accumulation at end of each interval = previous accumulation + vehicles in – vehicles out.

Time	In	Out	Accumulation
8:00	—	—	12
8:30	10	2	20

9:00	14	4	30
9:30	9	5	34
10:00	8	6	36
10:30	6	8	34
11:00	7	5	36
11:30	9	6	39
12:00	5	9	35
12:30	4	7	32
13:00	3	6	29

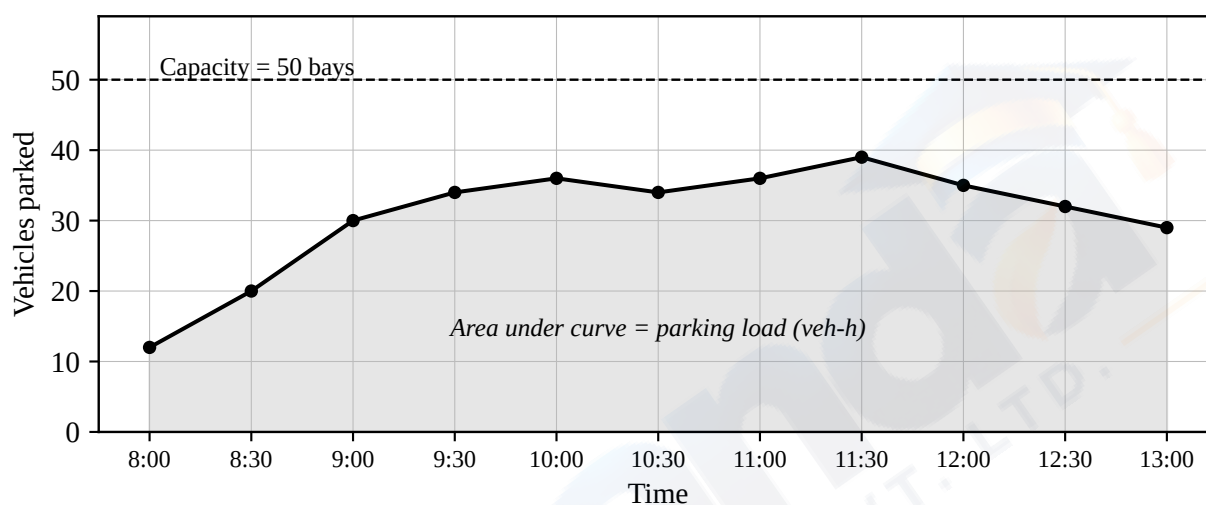


Fig.: Parking accumulation curve (8:00 to 13:00)

- **Peak accumulation** = 39 vehicles (at 11:30)
- **Parking load** = area under accumulation curve (trapezoidal rule, interval 0.5 h) = $0.5 \times \Sigma(\text{average of successive accumulations}) = 158.25 \text{ veh-h}$
- **Parking volume** = initially parked + vehicles entered = $12 + 75 = 87 \text{ vehicles}$
- **Average parking duration** = parking load / parking volume = $158.25 / 87 = 1.82 \text{ h}$ ($\approx 109 \text{ min}$)
- **Parking turnover** = parking volume / number of bays = $87 / 50 = 1.74 \text{ vehicles per bay in 5 h}$
- **Parking index** = peak accumulation / capacity $\times 100 = 39 / 50 \times 100 = 78.0 \%$

(Accumulation 1 M, load and volume 1 M, duration and turnover 1 M, index 1 M)

c) Journey time and delay study — floating car method.

4 M

- **Journey time:** total time taken by a vehicle to travel between two points, including all delays.
- **Running time:** time during which the vehicle is actually in motion (journey time minus stopped delays).
- **Delay:** time lost by a vehicle due to traffic friction or control — *fixed delay* (signals, level crossings, intersections) and *operational delay* (parking/unparking, turning vehicles, pedestrians, congestion).

Floating car method:

1. A test car is driven over the route several times (at least 6–8 runs) in each direction during the study period.
2. The driver "floats" with the traffic — overtakes as many vehicles as overtake the test car — so that the test car travels at the average speed of the stream.
3. An observer with stop-watches records the time of passing fixed control points (junctions, landmarks) and the location, cause and duration of every stop / delay.
4. Average journey time, running time, journey speed and delays for each section are then computed and shown on a map.

Uses:

- To find journey speed and identify the locations and causes of delay / congestion.
- For before-and-after studies of improvements (signals, one-way, widening).
- For economic studies (value of time) and route planning.

(Method 3 M, uses 1 M)

d) Parking requirement as per IRC (20 lakh city).

4 M

As per IRC:SP:12-2015 (Table 7.1), one car space (ECS) is required for every:

Recommended parking: one car space (ECS) for every ... (IRC:SP:12-2015, Table 7.1 — source NBC 2005 / MPD 2021)

Occupancy / city population →	< 50,000	50,000 – 2 lakh	2 – 10 lakh	10 – 50 lakh	> 50 lakh
Residential (tenements / flats)	—	—	2 tenements of 101–200 m ² built-up	1 tenement of 100 m ² built-up	1 tenement of 75 m ² built-up
Lodging / hotels	12 guest rooms	8 guest rooms	4 guest rooms	3 guest rooms	2 guest rooms
Mercantile (shops, markets)	300 m ²	200 m ²	100 m ²	50 m ²	25 m ²
Industrial	400 m ²	300 m ²	200 m ²	100 m ²	50 m ²

For a city of 20 lakh population (column 10 – 50 lakh):

1. Residential flats — 1 car space per tenement of 100 m² built-up area.
2. Hotels / lodging — 1 car space per 3 guest rooms.
3. Shops (mercantile) — 1 car space per 50 m² floor area.
4. Industrial buildings — 1 car space per 100 m² floor area.

Car stall size 2.5 m × 5.0 m; other vehicles converted to equivalent car space (two-wheeler 0.25 ECS, truck/bus 2.5 ECS).

(1 M each)

Q.3

a) Traffic volume and its uses in planning and design.

4 M

Traffic volume is the number of vehicles crossing a section of road per unit time at any selected period. It is expressed as vehicles per hour or vehicles per day; for mixed traffic it is converted into **Passenger Car Units (PCU)** per hour or per day.

Uses:

1. To find the relative importance of a road and decide priority of improvement and classification of the road.
2. To decide the number of lanes, width of carriageway and other geometric design elements (design hourly volume).
3. To design intersections — channelisation, rotaries, signal timing and turning lanes (from turning-movement counts).
4. For structural (pavement) design — number of commercial vehicles per day.
5. To study traffic trends and forecast future traffic for planning and economic studies.

(Definition 1 M, any three uses 3 M)

b) Benefits of ITS in surveys and management.

4 M

1. Automatic, continuous and accurate collection of traffic data (counts, speed, classification) using loops, cameras, radar and GPS probe vehicles — useful for traffic surveys.
2. Reduced congestion and travel time through adaptive signals and real-time information.
3. Improved safety — quick incident detection, warnings and enforcement.
4. Saving of fuel and reduction of air pollution due to smoother flow and less idling.
5. Better use of existing road capacity without major new construction.
6. Better public transport reliability and passenger information.

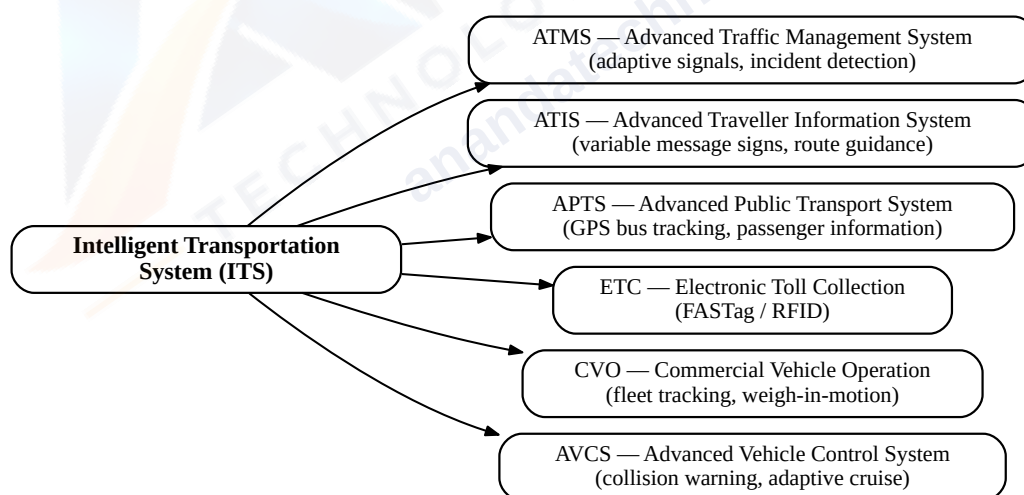


Fig.: Components / applications of Intelligent Transportation System (ITS)

(Any four benefits, 1 M each)

c) Ill effects of unregulated parking in CBD.

4 M

1. **Congestion:** parked vehicles reduce the effective width of carriageway and the capacity of the road; traffic speed reduces and delays increase.

2. **Accidents:** vehicles coming out of / going into parking, opening of doors, pedestrians emerging suddenly from behind parked vehicles cause accidents; parked vehicles near junctions block sight distance.
3. **Obstruction to emergency vehicles:** fire tenders and ambulances cannot reach buildings in time; fire hydrants get blocked.
4. **Environmental effects:** searching for parking, frequent stop-start and idling increase fuel consumption, air and noise pollution.
5. **Obstruction to pedestrians:** vehicles parked on footpaths force pedestrians to walk on the carriageway.
6. **Double parking and loss of aesthetics:** unregulated parking leads to double parking and spoils the appearance of the street.

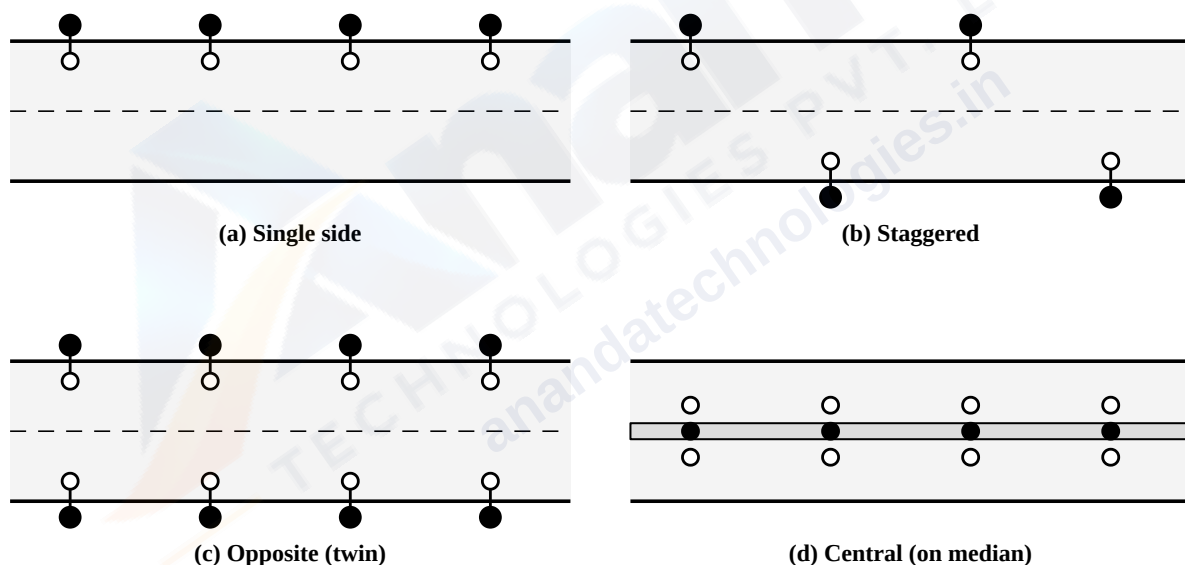
(Any four, 1 M each)

d) Necessity of street lighting; lamp arrangements.

4 M

Necessity:

1. Reduces night-time accidents by improving visibility of obstacles, pedestrians and road edges.
2. Increases speed and comfort of night driving; drivers feel confident.
3. Increases the night-time capacity of roads.
4. Reduces crime (theft, robbery) and gives a sense of security to pedestrians.



● pole ○ luminaire (lamp head)

Fig.: Arrangement of street lamps (plan)

- **Single side:** lamps on one side only — for narrow roads.
- **Staggered:** lamps alternately on both sides — medium-width roads.
- **Opposite (twin):** lamps facing each other on both sides — wide roads.
- **Central:** lamps on the median with two brackets — divided roads.

(Necessity 2 M, two arrangements with sketch 2 M)

Q.4

a) Gradient, curves, design speed and friction.

4 M

- **Gradient:** Steep gradient reduces the speed of heavy vehicles going up, increases braking distance and accident risk going down; ruling gradients are fixed according to terrain.
- **Curves (horizontal and vertical):** Sharp curves reduce safe speed and sight distance; proper radius, super-elevation, extra widening and transition curves are required.
- **Design speed:** All geometric elements (sight distance, curve radius, super-elevation, gradient) depend on the design speed of the road.
- **Friction between road and tyre:** Skid resistance of the pavement surface decides stopping distance and safe speed on curves; wet, smooth or oily surfaces reduce friction.

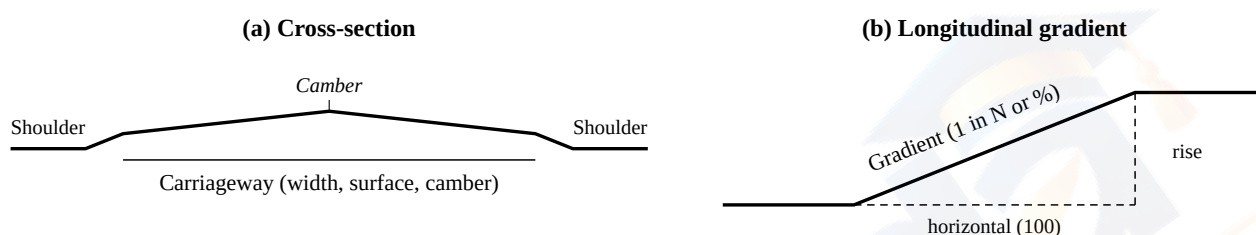


Fig.: Road characteristics — cross-section and longitudinal gradient

(1 M each)

b) Four factors affecting reaction time.

4 M

Reaction time is the time between seeing a hazard and starting the action (braking). It is affected by:

1. **Physical condition of driver:** fatigue, sleepiness, illness and poor eyesight increase reaction time.
2. **Alcohol and drugs:** slow down perception and judgement; reaction time increases considerably.
3. **Age and experience:** young inexperienced and elderly drivers generally react slower; experience reduces reaction time.
4. **Complexity of the situation:** more choices / more objects to watch (busy intersections) need more time to decide.
5. **Mental and emotional state:** anger, fear, impatience, worry or distraction (mobile phone, music) delay the decision.
6. **Environmental conditions:** poor visibility at night, fog, rain, glare and dust delay perception.

(Any four, 1 M each)

c) Discernment by silhouette; visibility at night.

4 M

Discernment by silhouette: At night most objects on the road are seen as **dark objects against a brighter background** (the lighted road surface). Street lighting is designed to make the road surface uniformly bright so that obstacles and pedestrians stand out. (Reverse silhouette — light object against a dark background — and surface detail are also used.)

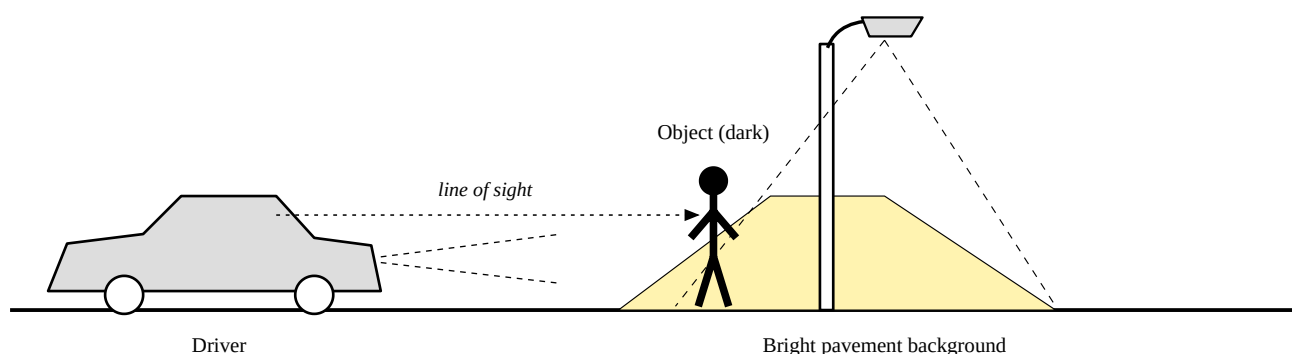


Fig.: Discernment by silhouette — dark object seen against bright road surface

Factors:

1. Amount and distribution of light
2. Brightness contrast
3. Glare
4. Size, colour and reflectivity of object
5. Reflection characteristics of road surface
6. Speed of vehicle

(Silhouette 2 M, factors 2 M)

d) Techniques of tree care and maintenance.

4 M

1. **Watering:** regular watering of young plants, especially in summer.
2. **Manuring and fertilising:** organic manure / fertiliser for healthy growth.
3. **Tree guards:** brick, iron or bamboo guards protect young plants from cattle, goats and vehicles.
4. **Staking:** support by stakes so that young plants grow straight.
5. **Pruning and trimming:** removal of dead, diseased and low branches to keep clearance for vehicles, signs and lights.
6. **Weeding, hoeing and mulching:** keeps soil loose, conserves moisture.
7. **Pest and disease control:** spraying of pesticides; lime / white-wash on trunks (also improves night visibility).
8. **Gap filling and protection:** replacing dead plants, protecting from fire, cutting and encroachment.

(Any four, 1 M each)

e) Preventive measures for road accidents.

4 M

1. **Engineering measures:** improve geometrics (sight distance, super-elevation, widening of curves), skid-resistant surface, proper signs, markings and signals, channelisation, street lighting, crash barriers, footpaths, foot over-bridges, speed calming near schools; treatment of black spots.
2. **Enforcement measures:** strict licensing tests, speed checks, drunk-driving checks, helmet and seat-belt rules, periodic vehicle fitness checks, control of overloading, CCTV / e-challan.

3. **Education measures:** road safety education in schools, driver training, campaigns, Road Safety Week, posters and media.
 4. **Vehicle measures:** regular maintenance, ABS brakes, airbags, reflective tapes, speed governors.
- (1 M each)

Q.5

a) On-street parking for a busy commercial street.

6 M

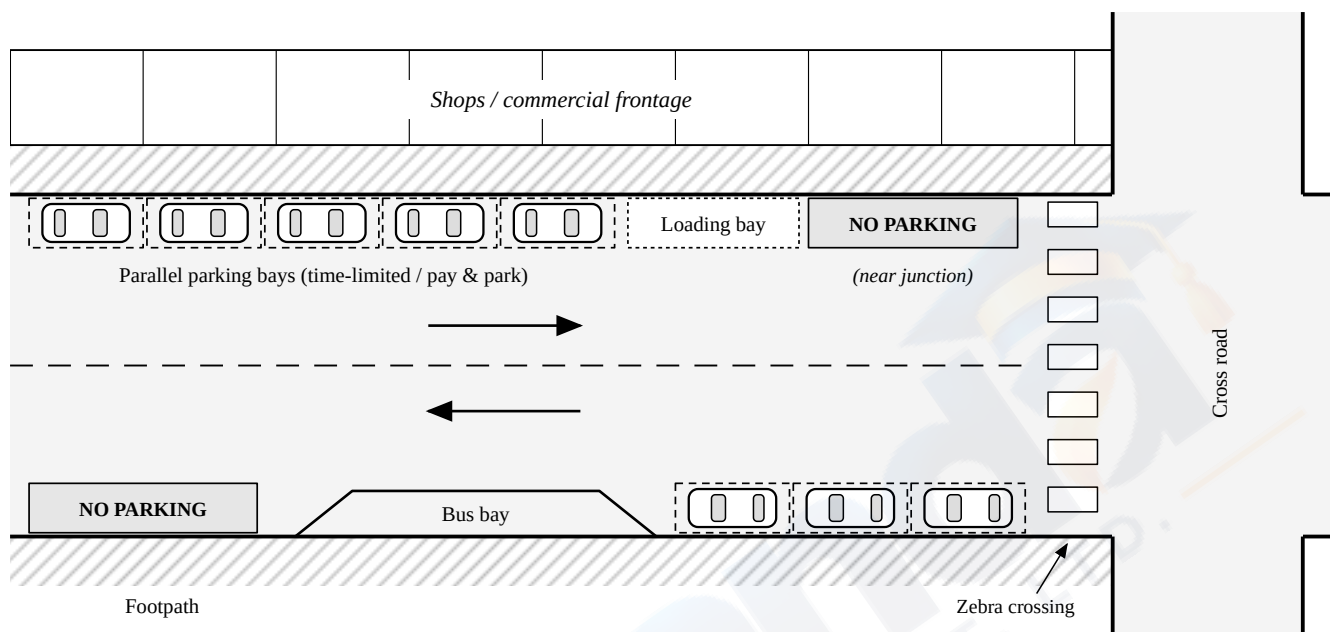


Fig.: On-street parking plan for a busy commercial street (generic sketch)

Provisions shown:

1. **Parallel parking** is used on a busy commercial street because it needs the least road width and is safest for moving traffic.
2. Parking bays are marked (2.5 m wide, about 5.9 m long per car) with time limits / pay-and-park to increase turnover.
3. **No-parking zones** near the junction, pedestrian crossing and opposite the bus bay keep sight distance and turning space free.
4. A separate **loading / unloading bay** for goods vehicles of shops (fixed hours).
5. A recessed **bus bay** so that buses stop out of the through lane.
6. Continuous **footpaths** and a zebra crossing for shoppers; no parking on footpaths.

Other layouts: angle parking (30°, 45°, 60°) and 90° parking accommodate more cars per kerb length but need more width — used only on wide, low-speed streets.

Type	Kerb length per car (m)	Width occupied from kerb (m)	Cars per 100 m of kerb
Parallel	5.90	2.50	16.9
30°	5.00	4.67	20.0
45°	3.54	5.30	28.3
60°	2.89	5.58	34.6

90°	2.50	5.00	40.0
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Computed for car stall $2.5 \text{ m} \times 5.0 \text{ m}$: kerb length = $2.5 / \sin \theta$, width = $5.0 \sin \theta + 2.5 \cos \theta$ (parallel parking: $5.0 \text{ m} +$ manoeuvring space $\approx 5.9 \text{ m}$).

(Sketch 3 M, explanation 3 M)

b) Off-street parking reduces congestion; multi-storey car park.

6 M

Off-street parking facilities: surface parking lots, multi-storey (ramp / mechanical) car parks, basement / underground parking, roof-top parking and park-and-ride lots.

How they reduce on-road congestion:

1. Removes parked vehicles from the carriageway — full width is available for moving traffic, capacity increases.
2. Reduces "cruising" for parking, stop-start and accidents due to parking/unparking.
3. Long-term (all-day) parkers are shifted off-street, on-street space is kept for short-term needs, loading and buses.
4. Organised entry/exit, pricing and guidance systems control demand.
5. Footpaths become free for pedestrians; fire and emergency access is improved.

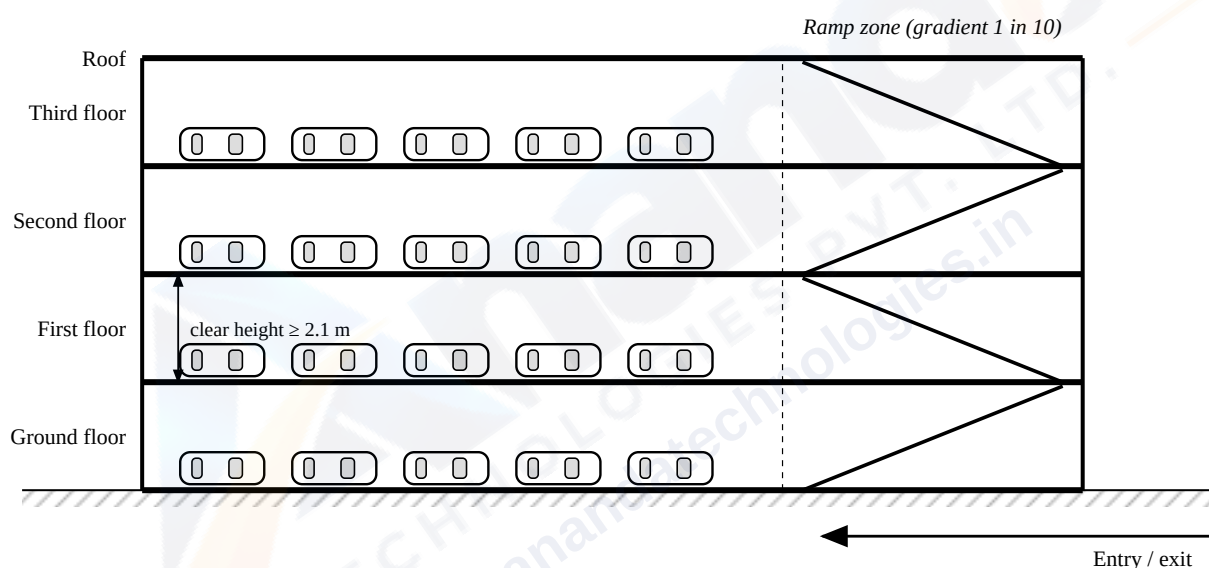


Fig.: Multi-storey car park (ramp type) — sectional elevation

(Explanation 4 M, sketch 2 M)

c) Factors for selecting roadside trees.

6 M

1. **Climate and soil:** species suitable to local rainfall, temperature and soil should be selected.
2. **Root system:** deep, non-spreading roots which do not damage the pavement, drains and footpaths.
3. **Height and spread of crown:** should give good shade without obstructing sight distance, signs, lights or overhead wires; high clear trunk.
4. **Evergreen nature:** evergreen / semi-evergreen trees give shade throughout the year and less leaf litter.
5. **Strength of branches:** branches should not be brittle and should not break easily in storms.

6. **Rate of growth and life span:** fast growing in early years and long life.
7. **Nature of fruits and thorns:** trees with heavy fruits, thorns or attracting animals/people (fruit plucking) are avoided.
8. **Resistance:** resistant to pests, diseases, drought and pollution; low water requirement.

(Any six, 1 M each)

Q.6

a) Spot speed — 85th and 98th percentile speeds, mean.

6 M

Step 1 — Cumulative frequency table: Mid speed = (lower + upper limit)/2; % frequency = $f / N \times 100$; cumulative % is plotted against the **upper limit** of each class.

Speed range (km/h)	Mid speed v (km/h)	No. of vehicles f	% frequency	Cumulative f	Cumulative %	$f \times v$
30 – 40	35	9	5.00	9	5.00	315
40 – 50	45	21	11.67	30	16.67	945
50 – 60	55	44	24.44	74	41.11	2420
60 – 70	65	58	32.22	132	73.33	3770
70 – 80	75	32	17.78	164	91.11	2400
80 – 90	85	11	6.11	175	97.22	935
90 – 100	95	5	2.78	180	100.00	475
Total		180	100.00			11260

Step 2 — Mean (average) spot speed = $\Sigma(f \cdot v) / N = 11260 / 180 = 62.56 \text{ km/h}$. Modal class = 60 – 70 km/h (maximum frequency 58).

Step 3 — Cumulative speed distribution curve: plot cumulative % (Y-axis) against upper speed limit (X-axis) and join the points by a smooth curve. Draw horizontal lines from the required percentages to meet the curve and read the speeds on X-axis.

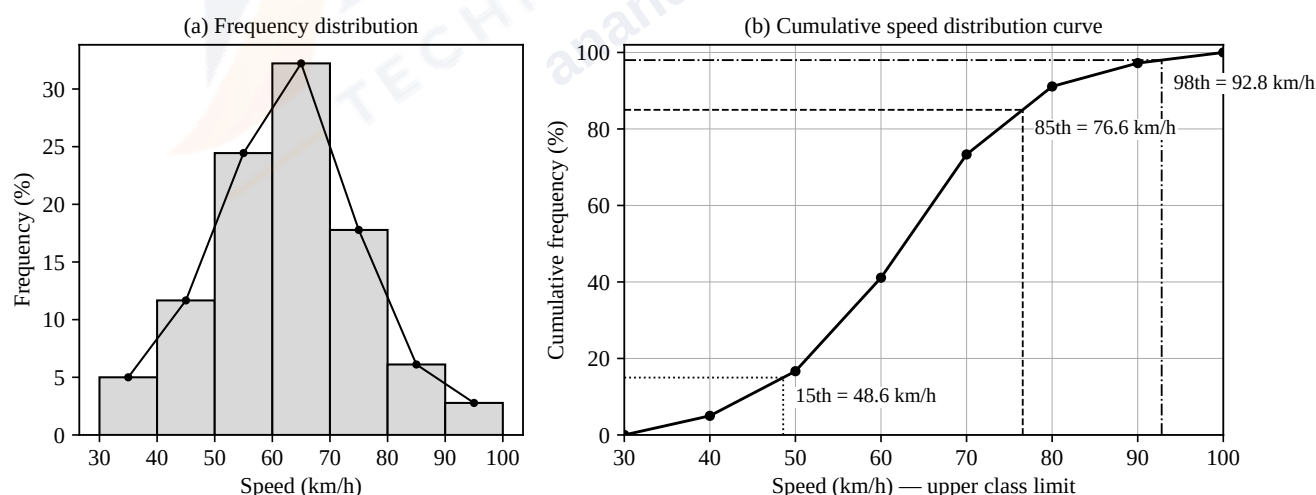


Fig.: Spot speed — frequency histogram and cumulative speed distribution curve

Step 4 — Values read from the curve (checked by linear interpolation between plotted points):

- **15th percentile speed:** 15 % lies between 5.00 % (40 km/h) and 16.67 % (50 km/h) → $V_{15} = 40 + (15 - 5.00) \times (50 - 40) / (16.67 - 5.00) = 48.57 \text{ km/h}$
- **85th percentile speed:** 85 % lies between 73.33 % (70 km/h) and 91.11 % (80 km/h) → $V_{85} = 70 + (85 - 73.33) \times (80 - 70) / (91.11 - 73.33) = 76.56 \text{ km/h}$
- **98th percentile speed:** 98 % lies between 97.22 % (90 km/h) and 100.00 % (100 km/h) → $V_{98} = 90 + (98 - 97.22) \times (100 - 90) / (100.00 - 97.22) = 92.80 \text{ km/h}$

Result: 85th percentile speed $\approx 76.6 \text{ km/h}$; a speed limit of about 75 km/h (rounded to the nearest 5 km/h) can be adopted for this section.

(Table 2 M, curve 2 M, percentiles and mean 2 M)

b) Legislation, enforcement, education and propaganda.

6 M

Legislation: Motor Vehicles Act, 1988 (amended 2019) and Central Motor Vehicles Rules, 1989 lay down rules for driving licences, registration, fitness of vehicles, insurance, speed limits, helmets, seat belts, drunk driving, overloading and penalties. State rules and municipal bye-laws control parking and local traffic.

Important provisions: compulsory driving licence and vehicle registration; insurance; speed limits; prohibition of drunk driving; compulsory helmets and seat belts; limits on axle load; higher penalties for offences (2019 amendment).

Law enforcement:

- Traffic police check speed (radar guns, cameras), drunk driving (breath analyser), helmets and seat belts.
- Strict tests before issue of driving licence; cancellation/suspension of licence of offenders.
- Periodic fitness checks of vehicles and control of overloading.
- CCTV and ANPR based e-challan for signal jumping and over-speeding; heavy fines act as deterrent.
- Removal of encroachments and illegal parking.

Education and propaganda:

- Road safety education in schools and colleges (rules, signs, safe crossing).
- Training of drivers at driving schools; refresher courses for heavy vehicle drivers.
- Propaganda through TV, radio, newspapers, social media, posters, hoardings and films.
- Observing Road Safety Week / Month, campaigns and competitions.
- Educating pedestrians and cyclists about their safety.

(Legislation 2 M, enforcement 2 M, education 2 M)

c) Collision diagram for the given records; remedial measures.

6 M

Collision diagram: A schematic diagram (not to scale) of the accident location on which each accident is shown by standard symbols — arrows indicate the paths of the vehicles / pedestrians involved, and symbols show the type of collision and severity (fatal, injury, property damage), with date, time and weather. It shows the **pattern of accidents** (e.g. many right-angle or rear-end collisions) at the location.

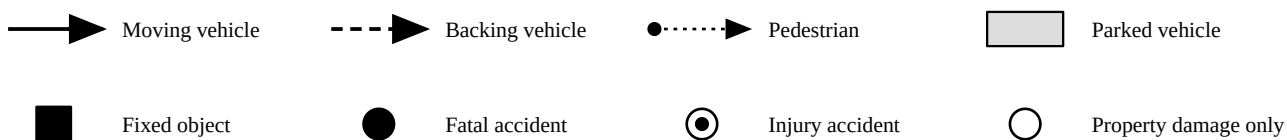


Fig.: Symbols commonly used in a collision diagram

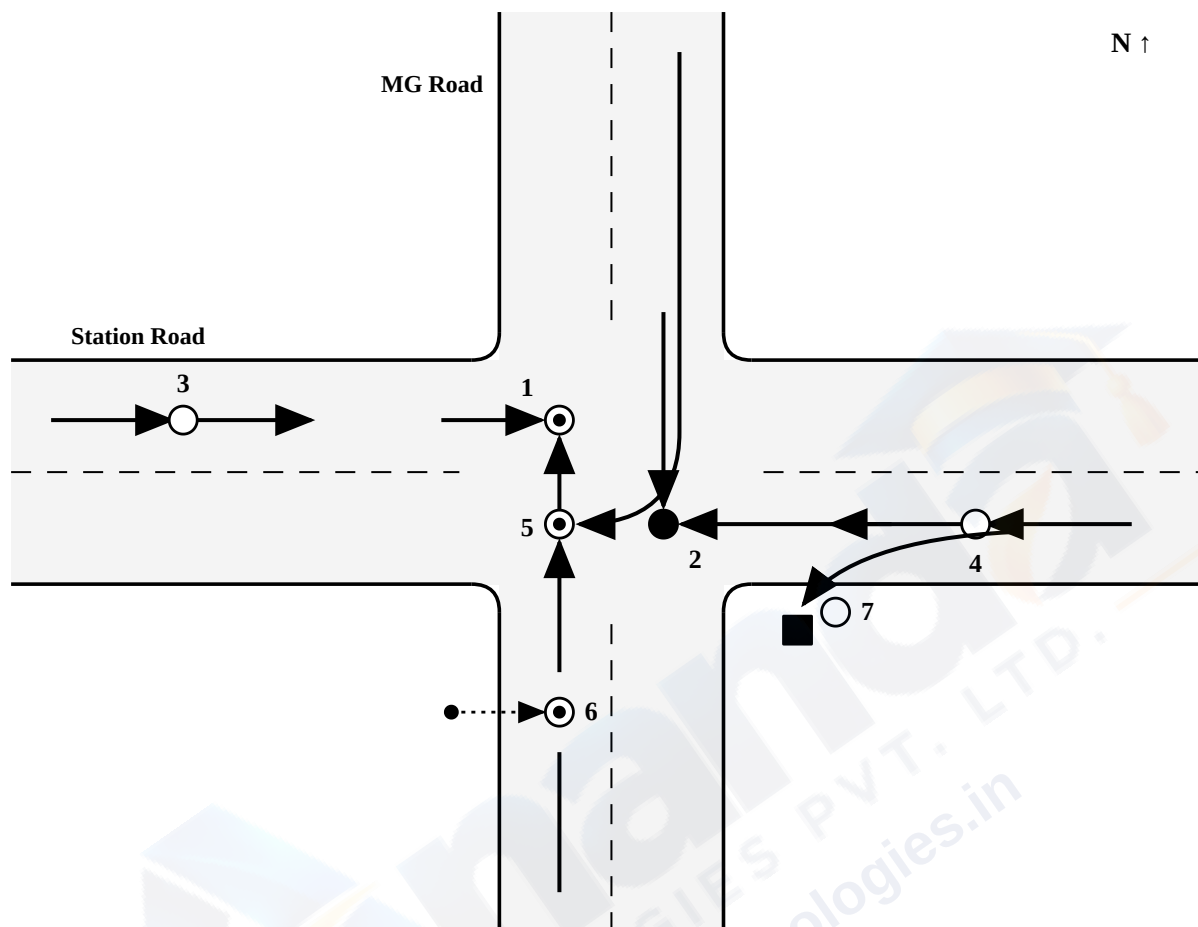


Fig.: Collision diagram — accidents 1 to 7 plotted at an intersection (schematic)

Observations: two right-angle collisions inside the junction (one fatal), a right-turn collision, a pedestrian accident and two rear-end collisions on the approaches; five of the seven accidents occurred after dark (18:40 onwards).

Remedial measures:

- Install traffic signals (with separate right-turn phase) to control crossing and turning conflicts.
- Improve street lighting at the junction and pedestrian crossing.
- Provide zebra crossing with pedestrian signal / refuge on the south arm.
- Skid-resistant surface and advance warning signs on the approaches; relocate / protect the lamp post with a kerb.

(Explanation 2 M, collision diagram 3 M, remedial measures 1 M)

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