

Road Traffic Engineering (315318)

Model Question Paper — Set C · Model Answers

Q.1

a) Scope of traffic engineering.

2 M

1. **Traffic characteristics**
2. **Traffic studies and analysis**
3. **Traffic operation — control and regulation**
4. **Planning and analysis**
5. **Geometric design**
6. **Administration and management**

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

b) Vehicular characteristics affecting road design.

2 M

1. **Width** — decides width of traffic lane, carriageway and parking stall (IRC maximum 2.5 m).
2. **Height** — decides clearance under bridges, overhead lines and the driver eye height for sight distance (IRC maximum 3.8 m; 4.2 m for double-deckers).
3. **Length** — decides extra widening on curves, turning radius, parking and overtaking distance (IRC maximum 11 m single unit, 16 m semi-trailer, 18 m truck-trailer).
4. **Weight and axle load** — decides pavement thickness, bridge design and gradient performance.

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

c) 85th percentile speed and its use.

2 M

85th percentile speed is the speed at or below which 85 % of the vehicles travel at a spot (read from the cumulative speed distribution curve).

Use: it is adopted as the safe upper **speed limit** for regulating traffic on that road.

(Definition 1 M, use 1 M)

d) Desire line diagram.

2 M

Desire line diagram is a graphical representation of O-D data in which the zone centroids are joined by straight lines (desire lines), the **thickness of each line being proportional to the number of trips** between the two zones. It shows the desired direction of travel irrespective of the actual routes.

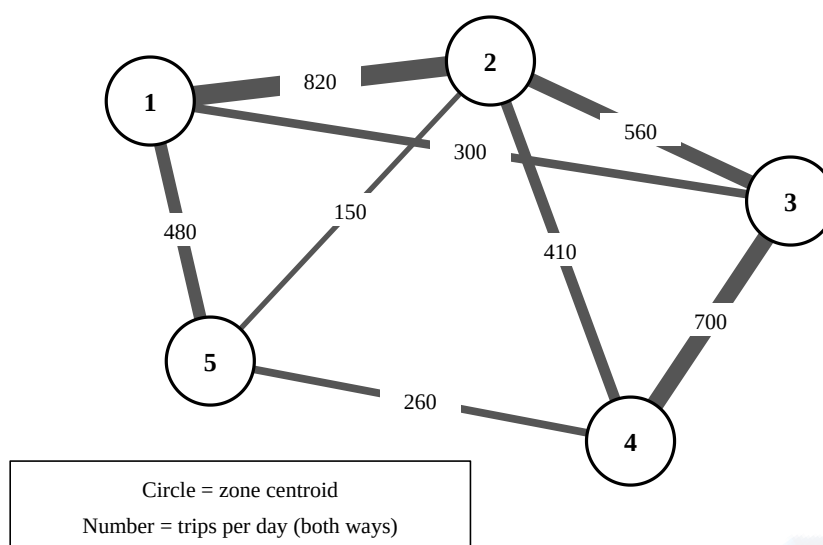


Fig.: Desire line diagram (sample O-D data; thickness $\propto$ trips)

(Definition 1 M, sketch 1 M)

e) Parking index and parking load.

2 M

i) Parking index: the ratio of the number of bays occupied (accumulation) to the total parking bays available, expressed as a percentage — Parking index = (accumulation / capacity) $\times$ 100.

ii) Parking load: the area under the parking accumulation curve during the study period; it gives the total vehicle-hours of parking.

(1 M each)

f) Sources of light for street lighting.

2 M

1. Incandescent (filament) lamps — old, low efficiency.
2. Fluorescent tube lights.
3. Mercury vapour lamps.
4. Sodium vapour lamps (low pressure and high pressure) — yellow light, high efficiency, good in fog.
5. Metal halide lamps — white light.
6. LED (light emitting diode) luminaires — now most common: high efficiency, long life, low maintenance.

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

g) Key elements in a road accident.

2 M

1. Road user — driver, pedestrian, cyclist (human factor).
2. Vehicle — its condition and characteristics.
3. Road — geometry, surface and traffic control devices.
4. Environment — weather, light (day/night) and surroundings.

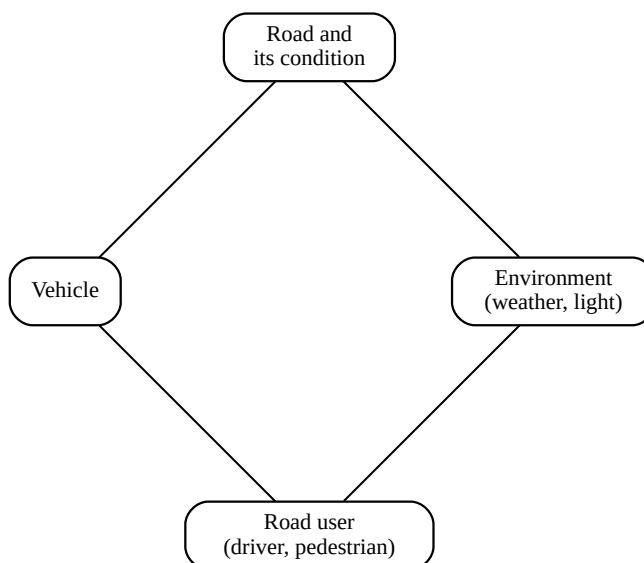


Fig.: Key elements involved in a road accident

(½ M each)

Q.2

a) Effect of gradient, curves, design speed and skid resistance.

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.

(1 M each)

b) Factors affecting reaction time — PIEV.

4 M

The total reaction time (PIEV time) = Perception + Intellection + Emotion + Volition time; IRC adopts 2.5 s for design. Each stage is affected by the following factors:

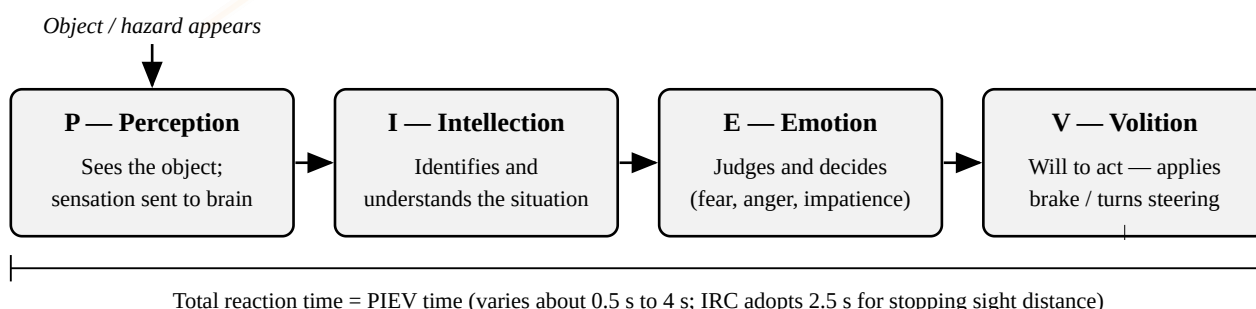


Fig.: PIEV theory — sequence of driver reaction

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.

(PIEV 1 M, any three factors 3 M)

c) Purposes of traffic volume study.

4 M

Traffic volume study is the field survey in which the number and type (classification) of vehicles and pedestrians passing a road section or intersection are counted in a specified time interval and direction, to know the traffic flow, its variation and composition.

1. To design intersections — channelisation, rotaries, signal timing and turning lanes (from turning-movement counts).
2. For structural (pavement) design — number of commercial vehicles per day.
3. To study traffic trends and forecast future traffic for planning and economic studies.
4. To find capacity and level of service of a road and identify congested sections.
5. To plan pedestrian facilities, parking, bus stops, one-way streets and traffic regulation.

(Any four, 1 M each)

d) Home interview and licence-plate methods.

4 M

1) Home interview method:

- The study area is divided into zones and a sample of households (about 5–20 %, depending on population) is selected.
- Trained interviewers visit the houses and record all trips made by each member on the previous day — origin, destination, purpose, mode, time of start and end.
- Socio-economic data (income, vehicle ownership, family size) are also collected.
- It gives the most complete information on travel pattern but is costly and time consuming.

2) Licence-plate method:

- Observers are posted at all entry and exit points of the area (cordon).
- They note the registration number of each vehicle and the time of passing.
- By matching the numbers recorded at different stations, the route, origin-destination (within the area) and travel time are found.
- Vehicles are not stopped, so there is no delay; but the purpose of trip is not known.

(2 M each)

Q.3

a) Benefits of ITS in traffic surveys.

4 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.

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.

(Any four benefits, 1 M each)

b) Measures for pedestrian safety.

4 M

1. Continuous footpaths of adequate width, free from encroachment, with kerb separating them from the carriageway.
2. Zebra crossings at proper locations with pedestrian signals at busy junctions.
3. Refuge islands / medians on wide roads so that pedestrians can cross in two stages.
4. Foot over-bridges or subways on high-speed and heavy-traffic roads.
5. Pedestrian guard rails to prevent crossing at random points and to guide pedestrians to crossings.
6. Good street lighting at crossings; speed calming (humps, rumble strips) near schools, hospitals and markets.

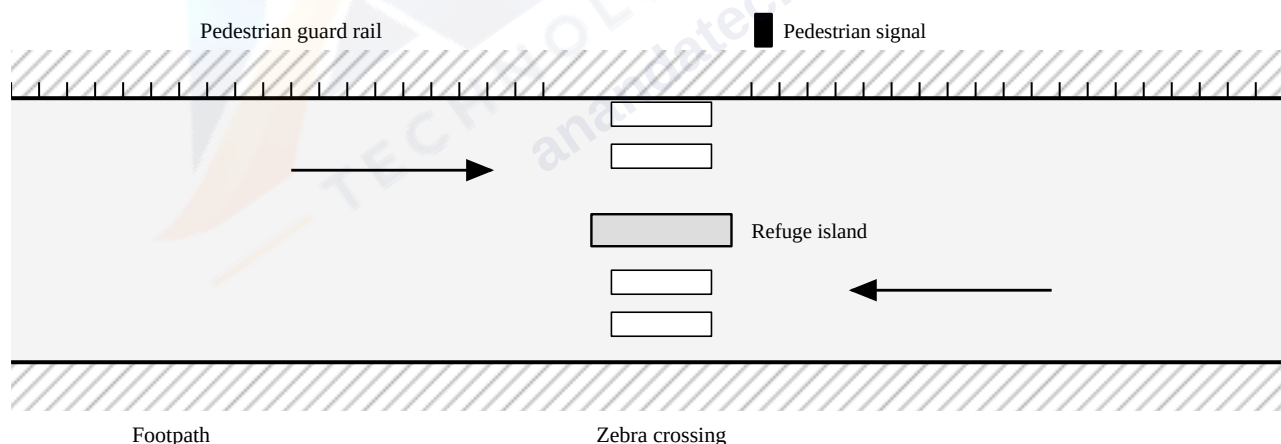


Fig.: Pedestrian facilities at a mid-block crossing (plan)

(Any four measures, 1 M each)

c) Parking spaces as per IRC (numerical).

4 M

As per IRC:SP:12-2015, Table 7.1, for a city of population 10 to 50 lakh (here 15 lakh), one car space (ECS) is required for every 50 m² of mercantile area, every 5 beds of a private hospital and

every 15 seats of a cinema.

Building	Norm (one ECS)	Calculation	ECS required
Shopping complex (mercantile), built-up area 4,200 m ²	1 per 50 m ²	$4,200 / 50 = 84.0$	84
Private hospital of 120 beds	1 per 5 beds	$120 / 5 = 24.0$	24
Cinema hall of 600 seats	1 per 15 seats	$600 / 15 = 40.0$	40
Total			148

Total car spaces required = 148 ECS (fractions rounded up). With a stall of $2.5 \text{ m} \times 5.0 \text{ m} = 12.5 \text{ m}^2$ per car (excluding aisles), net stall area = $148 \times 12.5 = 1,850.0 \text{ m}^2$.

(Norms 1 M, calculations 2 M, total 1 M)

d) Ill effects of unregulated parking.

4 M

- Congestion:** parked vehicles reduce the effective width of carriageway and the capacity of the road; traffic speed reduces and delays increase.
- 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.
- Obstruction to emergency vehicles:** fire tenders and ambulances cannot reach buildings in time; fire hydrants get blocked.
- Environmental effects:** searching for parking, frequent stop-start and idling increase fuel consumption, air and noise pollution.
- Obstruction to pedestrians:** vehicles parked on footpaths force pedestrians to walk on the carriageway.

(Any four, 1 M each)

Q.4

a) Necessity of street lighting; luminaire.

4 M

Necessity:

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

Luminaire: a complete lighting unit consisting of the lamp(s) together with the parts designed to distribute the light (reflector, refractor), to position and protect the lamp (housing, cover) and to connect it to the power supply (ballast/driver, fittings). It is mounted on a pole/bracket at a suitable height.

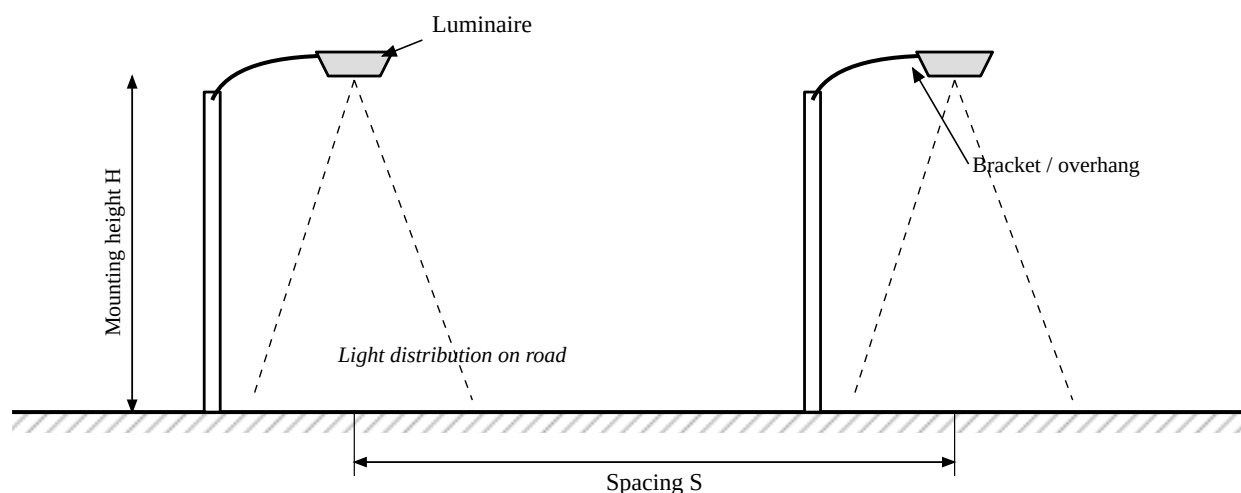


Fig.: Street light — luminaire, mounting height, overhang and spacing (elevation)

(Necessity 2 M, luminaire 2 M)

b) Factors affecting visibility at night.

4 M

1. **Glare:** from headlights of opposite vehicles and badly designed lamps reduces the ability to see.
2. **Size, colour and reflectivity of object:** small, dark coloured objects and pedestrians in dark clothes are difficult to see.
3. **Reflection characteristics of road surface:** wet and dark bituminous surfaces reflect less light towards the driver.
4. **Speed of vehicle:** less time is available to see and react at high speed.
5. **Weather conditions:** fog, rain, mist, smoke and dust scatter the light.
6. **Driver eyesight and age; condition of headlights and windscreen:** poor vision, dirty windscreen or dim headlights reduce visibility.

(Any four, 1 M each)

c) Factors for selection of roadside trees.

4 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.

(Any four, 1 M each)

d) Arboriculture — definition and objectives.

4 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.

Objectives:

1. To reduce air pollution (absorb dust and gases) and traffic noise.
2. To improve the beauty (aesthetics) of the road and surroundings.
3. To guide drivers along the alignment, especially at night and in fog.
4. To reduce headlight glare when planted on the median; act as wind-breaks.
5. To prevent soil erosion and stabilise embankment slopes.
6. To maintain ecological balance and provide habitat for birds; may give revenue (fruits / timber).

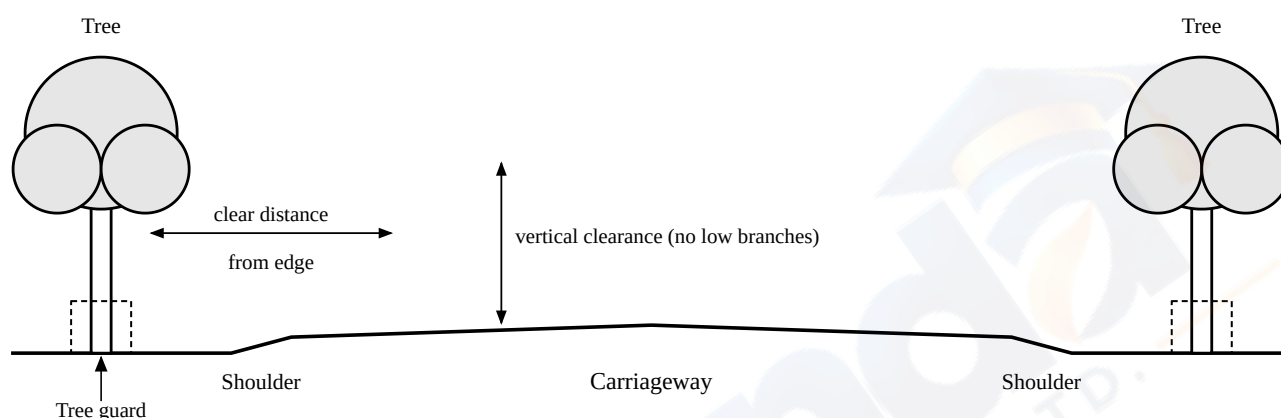


Fig.: Roadside tree plantation — typical cross-section (generic, not to scale)

(Definition 1 M, objectives 3 M)

e) Causes of road accidents.

4 M

1. **Road user (driver):** over-speeding, rash and careless driving, drunken driving, fatigue, use of mobile phone, violation of traffic rules, wrong overtaking.
2. **Pedestrians and cyclists:** careless crossing, walking on carriageway, not using zebra crossings / foot over-bridges.
3. **Vehicle defects:** failure of brakes or steering, tyre burst, poor headlights, overloading.
4. **Road conditions:** slippery or uneven surface, potholes, sharp curves, inadequate sight distance, narrow roads and bridges, poor lighting.
5. **Weather:** fog, heavy rain, dust storms — low visibility and slippery road.
6. **Other causes:** improper parking, stray animals, lack of traffic control at junctions, poor enforcement, encroachments, roadside advertisements distracting drivers.

(Any four, 1 M each)

Q.5

a) Moving observer method — flow and journey speed.

6 M

Moving observer method (Wardrop and Charlesworth): A test vehicle runs along the section in both directions. In each run the journey time (t), number of vehicles overtaking the test vehicle, number overtaken by it and number of opposing vehicles met (x) are recorded.

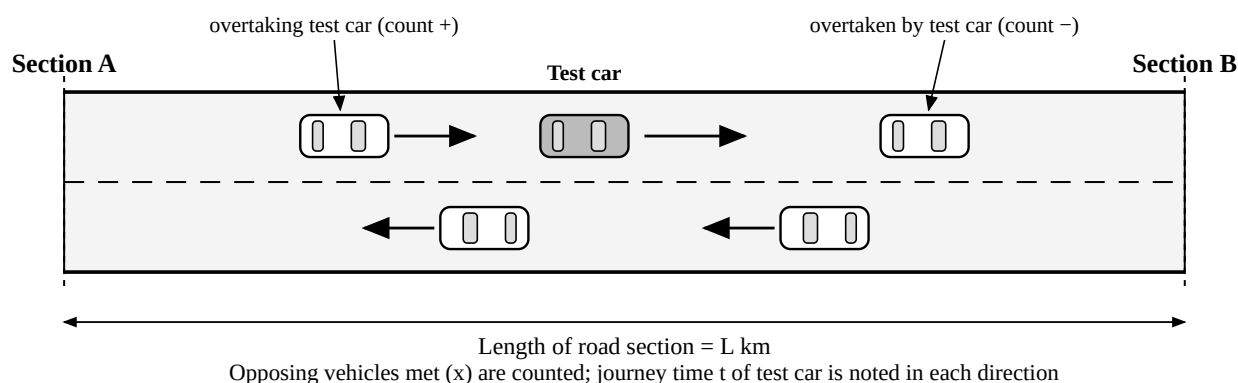


Fig.: Moving observer (moving car) method — test vehicle runs A → B and B → A

Formulae (for stream A → B):

- Flow $q_{AB} = (x_{BA} + y_{AB}) / (t_{BA} + t_{AB})$
- Mean journey time $\bar{t}_{AB} = t_{AB} - y_{AB} / q_{AB}$; journey speed = $L / \bar{t}_{AB}$
- x_{BA} = vehicles of A → B stream met when test car travels B → A; y_{AB} = (overtaking – overtaken) when test car travels A → B; t in minutes.

Given data:

Run	Direction	Journey time t (min)	Overtaking test car	Overtaken by test car	Opposing vehicles met x
1	A → B	4.20	3	1	92
2	A → B	4.45	5	2	88
3	A → B	4.10	2	1	95
4	A → B	4.35	4	3	90
1	B → A	4.60	4	2	110
2	B → A	4.80	2	1	104
3	B → A	4.50	3	2	108
4	B → A	4.70	5	1	112

Step 1 — Averages of the runs:

- A → B: $t_{AB} = 4.28$ min; $y_{AB} = 3.50 - 1.75 = 1.75$; opposing vehicles met $x_{AB} = 91.25$
- B → A: $t_{BA} = 4.65$ min; $y_{BA} = 3.50 - 1.50 = 2.00$; opposing vehicles met $x_{BA} = 108.50$

Step 2 — Stream A → B: $q_{AB} = (x_{BA} + y_{AB}) / (t_{BA} + t_{AB}) = (108.50 + 1.75) / (4.65 + 4.28) = 12.353$ veh/min = **741 veh/h**

$\bar{t}_{AB} = 4.28 - 1.75 / 12.353 = 4.133$ min; journey speed = $2.4 / (4.133 / 60) = 34.84$ km/h

Step 3 — Stream B → A: $q_{BA} = (x_{AB} + y_{BA}) / (t_{AB} + t_{BA}) = (91.25 + 2.00) / (4.28 + 4.65) = 10.448$ veh/min = **627 veh/h**

$\bar{t}_{BA} = 4.65 - (2.00) / 10.448 = 4.459$ min; journey speed = $2.4 / (4.459 / 60) = 32.30$ km/h

Direction	Flow (veh/h)	Mean journey time (min)	Journey (space-mean) speed (km/h)
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A → B	741	4.13	34.84
B → A	627	4.46	32.30

(Method 2 M, flow 2 M, journey speed 2 M)

b) Volume data representation; PCU and hourly variation chart.

6 M

(i) Methods of representation:

Method	What it shows / use
Annual average daily traffic (AADT) table / trend chart	shows yearly growth of traffic; used for planning and forecasting.
Hourly variation chart	bar chart of volume in each hour — shows the peak hour; used for design hourly volume and signal timing.
Daily and seasonal variation charts	show variation over days of week and months of year.
Traffic flow map	volume on each road link of a network drawn as a band whose width is proportional to the volume.
Intersection flow diagram	volume of each turning movement (left, straight, right) of each approach drawn to scale at the junction.
30th highest hourly volume curve	hourly volumes of the year arranged in descending order; the 30th highest is generally adopted as design hourly volume.

Suitable for a congested urban intersection: the **intersection flow diagram** (turning-movement counts of the peak hour, drawn to scale) together with the **hourly variation chart**. Signal timing, channelisation and turning lanes depend on the volume of each turning movement in the peak hour, which only the flow diagram shows directly.

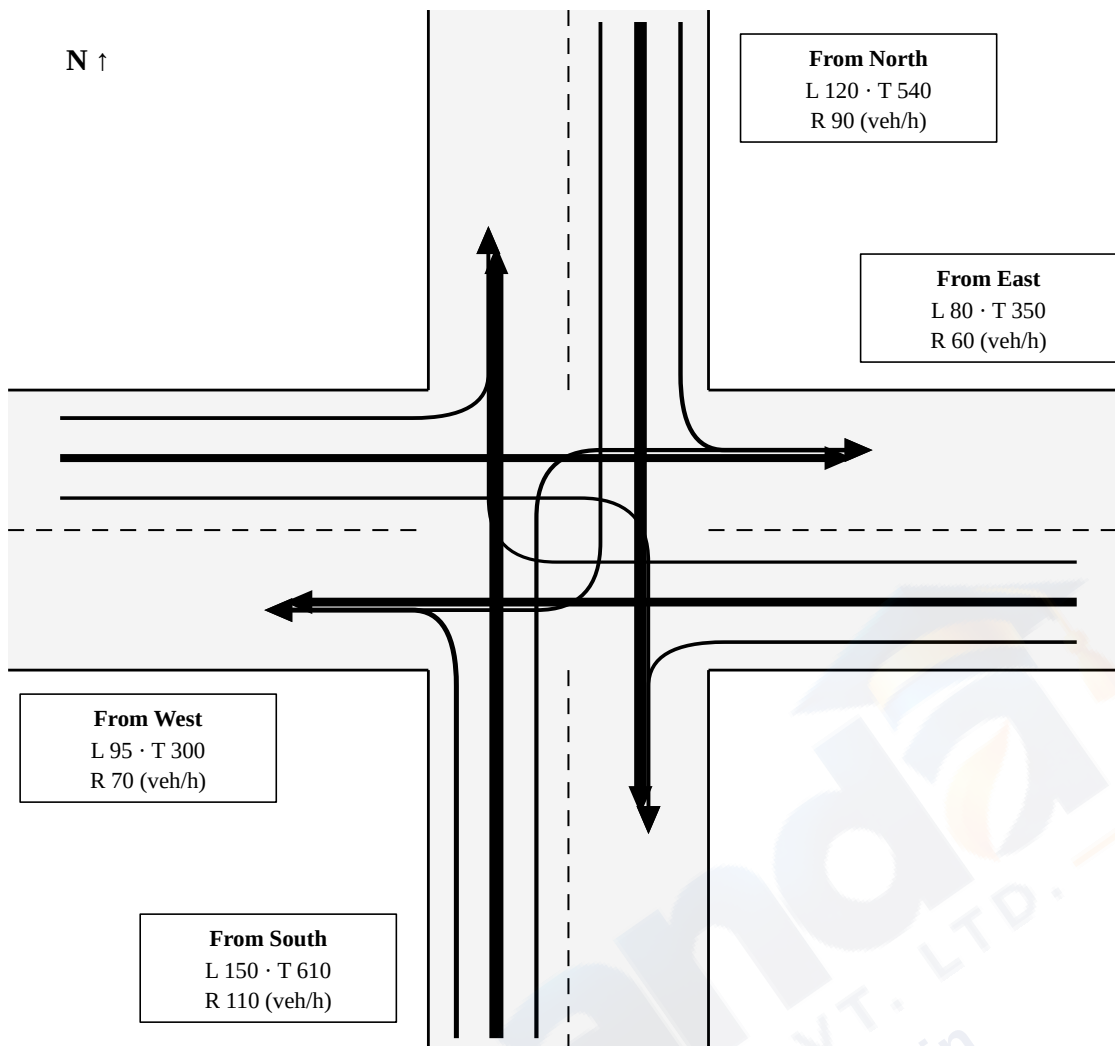


Fig.: Intersection flow diagram — peak-hour turning movements (sample counts, veh/h)

(ii) Conversion to PCU (factors: motor cycle 0.5, car/auto 1.0, LCV 1.5, truck/bus 3.0, cycle 0.5 — IRC:64-1990):

Hour	Motor cycle/ scooter	Passenger car/ auto-rickshaw	Light commercial vehicle	Truck/ bus	Cycle	Total vehicles	PCU/h
7–8	420	260	40	55	90	865	740
8–9	610	380	52	70	120	1232	1033
9–10	780	520	60	82	95	1537	1293.5
10–11	690	470	66	90	70	1386	1219
11–12	540	410	58	96	60	1164	1085
12–13	500	380	50	88	55	1073	996.5

Example (9–10 h): $780 \times 0.5 + 520 \times 1 + 60 \times 1.5 + 82 \times 3 + 95 \times 0.5 = 1293.5 \text{ PCU}$.

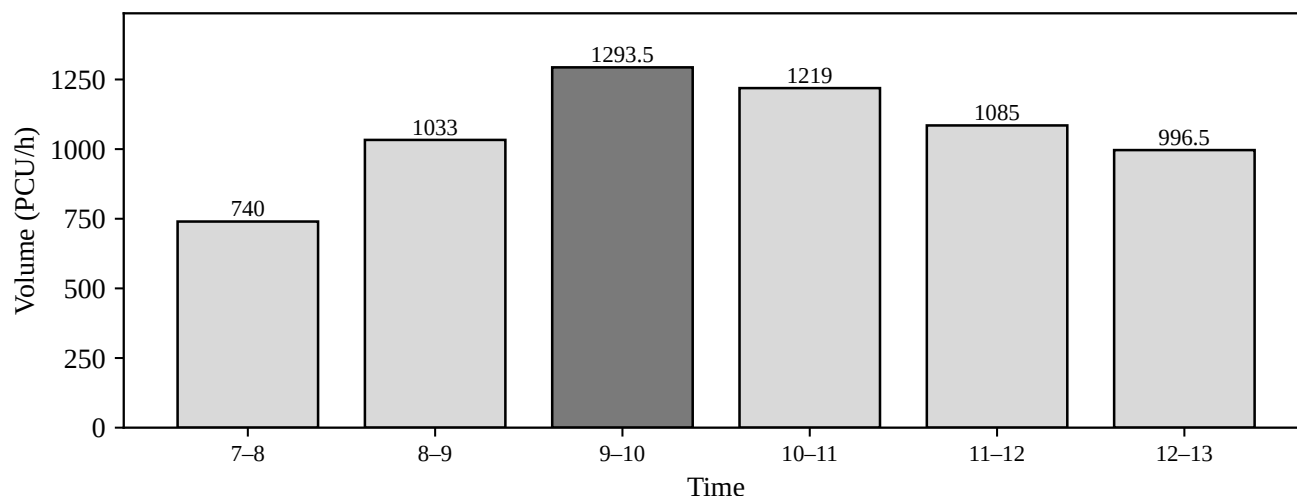


Fig.: Hourly variation chart (peak hour shaded dark)

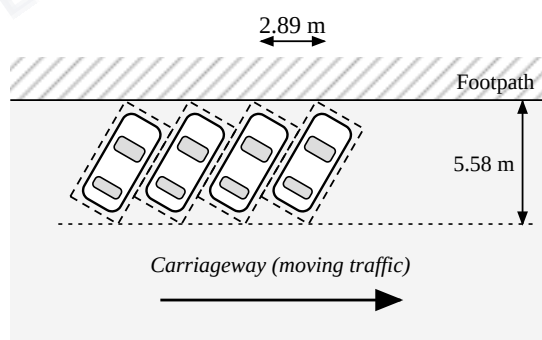
Peak hour: 9–10 h with 1293.5 PCU/h (1537 vehicles).

(Comparison and suggestion 2 M, PCU table 2 M, chart and peak hour 2 M)

c) On-street vs off-street parking; sketches.

6 M

Sr.	Parameter	On-street parking	Off-street parking
1	Location	On the carriageway along the kerb.	Away from the carriageway — lots, buildings, basements.
2	Effect on traffic	Reduces effective road width and capacity; causes congestion.	Full road width available for moving traffic.
3	Safety	Accidents due to parking / unparking, door opening, hidden pedestrians.	Safer; conflicts limited to entry / exit points.
4	Cost	Cheap — no land or building needed.	Costly — land, construction and operation.
5	Convenience	Very close to destination; suitable for short-term parking.	May need walking; suitable for long-term parking.
6	Capacity / control	Limited by kerb length; difficult to control.	Large capacity (multi-storey); easy to control and charge.



60° angle parking

Fig.: On-street 60° angle parking (kerb length 2.89 m and width 5.58 m per car)

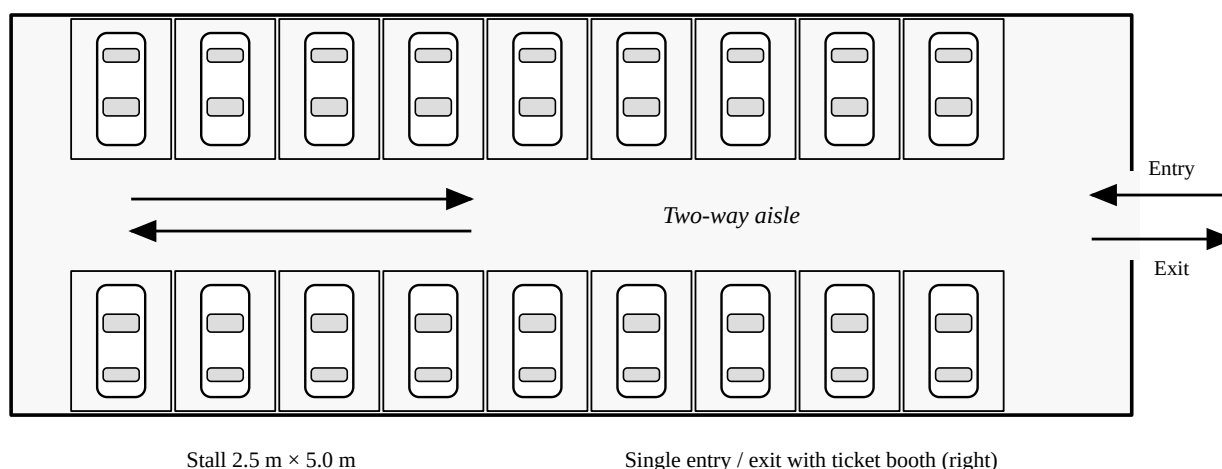


Fig.: Off-street surface car park (90° stalls on both sides of a two-way aisle)

(Any four points of comparison 4 M, two sketches 2 M)

Q.6

a) Spot speed — 15th, 85th, 98th percentile, mean, speed limit.

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 × v
25 – 35	30	4	2.86	4	2.86	120
35 – 45	40	15	10.71	19	13.57	600
45 – 55	50	31	22.14	50	35.71	1550
55 – 65	60	47	33.57	97	69.29	2820
65 – 75	70	26	18.57	123	87.86	1820
75 – 85	80	12	8.57	135	96.43	960
85 – 95	90	5	3.57	140	100.00	450
Total		140	100.00			8320

Step 2 — Mean (average) spot speed = $\Sigma(f \cdot v) / N = 8320 / 140 = 59.43 \text{ km/h}$. Modal class = 55 – 65 km/h (maximum frequency 47).

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.

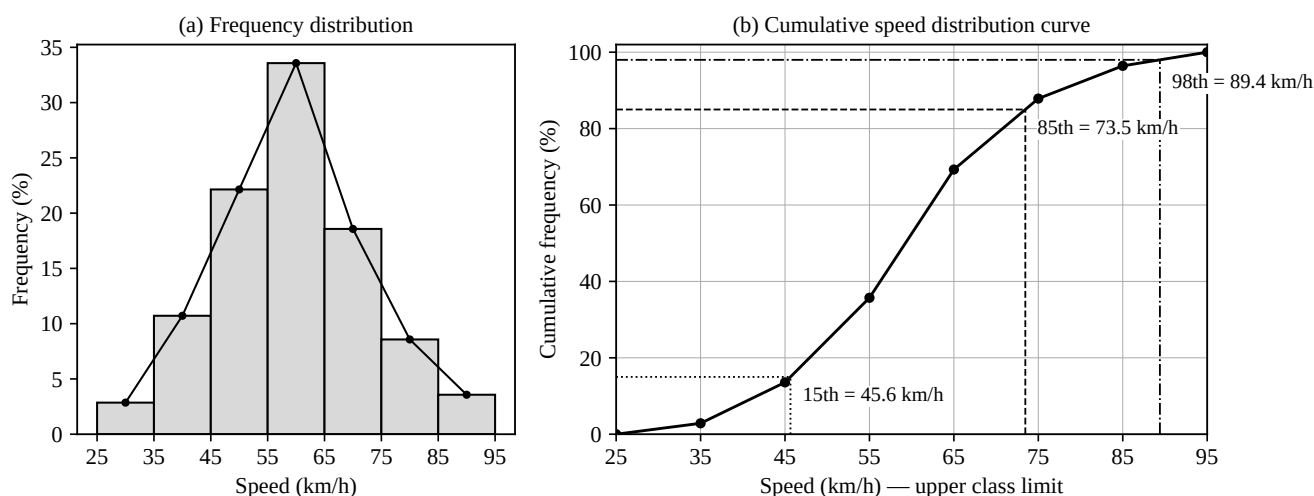


Fig.: Spot speed — frequency histogram and cumulative speed distribution curve

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

- **15th percentile speed:** 15 % lies between 13.57 % (45 km/h) and 35.71 % (55 km/h) → $V_{15} = 45 + (15 - 13.57) \times (55 - 45) / (35.71 - 13.57) = 45.65 \text{ km/h}$
- **85th percentile speed:** 85 % lies between 69.29 % (65 km/h) and 87.86 % (75 km/h) → $V_{85} = 65 + (85 - 69.29) \times (75 - 65) / (87.86 - 69.29) = 73.46 \text{ km/h}$
- **98th percentile speed:** 98 % lies between 96.43 % (85 km/h) and 100.00 % (95 km/h) → $V_{98} = 85 + (98 - 96.43) \times (95 - 85) / (100.00 - 96.43) = 89.40 \text{ km/h}$

Result: 85th percentile speed $\approx 73.5 \text{ km/h}$; a speed limit of about 75 km/h (rounded to the nearest 5 km/h) can be adopted for this section.

15th percentile speed $\approx 45.6 \text{ km/h}$ may be used as the minimum speed (lower limit) and 98th percentile $\approx 89.4 \text{ km/h}$ for checking geometric design.

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

b) Collision diagram with symbols; condition diagram.

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.

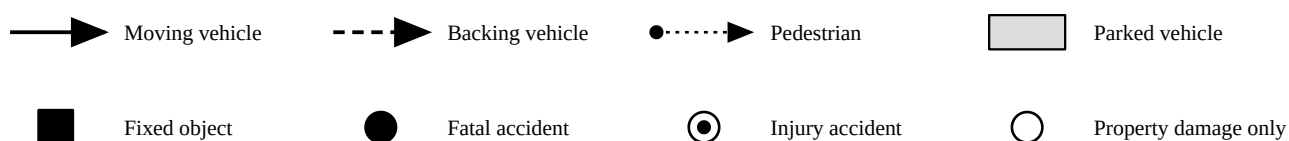


Fig.: Symbols commonly used in a collision diagram

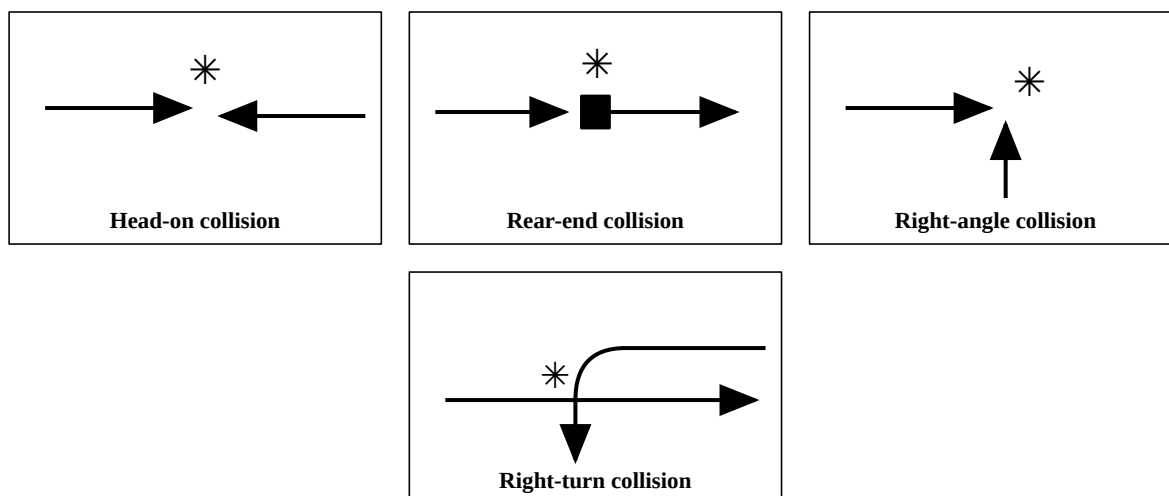


Fig.: Typical collision patterns shown on a collision diagram

Condition diagram: A drawing **to scale** of the accident location showing all the important **physical features** — carriageway and kerb lines, widths, footpaths, islands, traffic signs, signals, markings, street lights, bus stops, parking, driveways, buildings, trees and other obstructions to view, and surface condition.

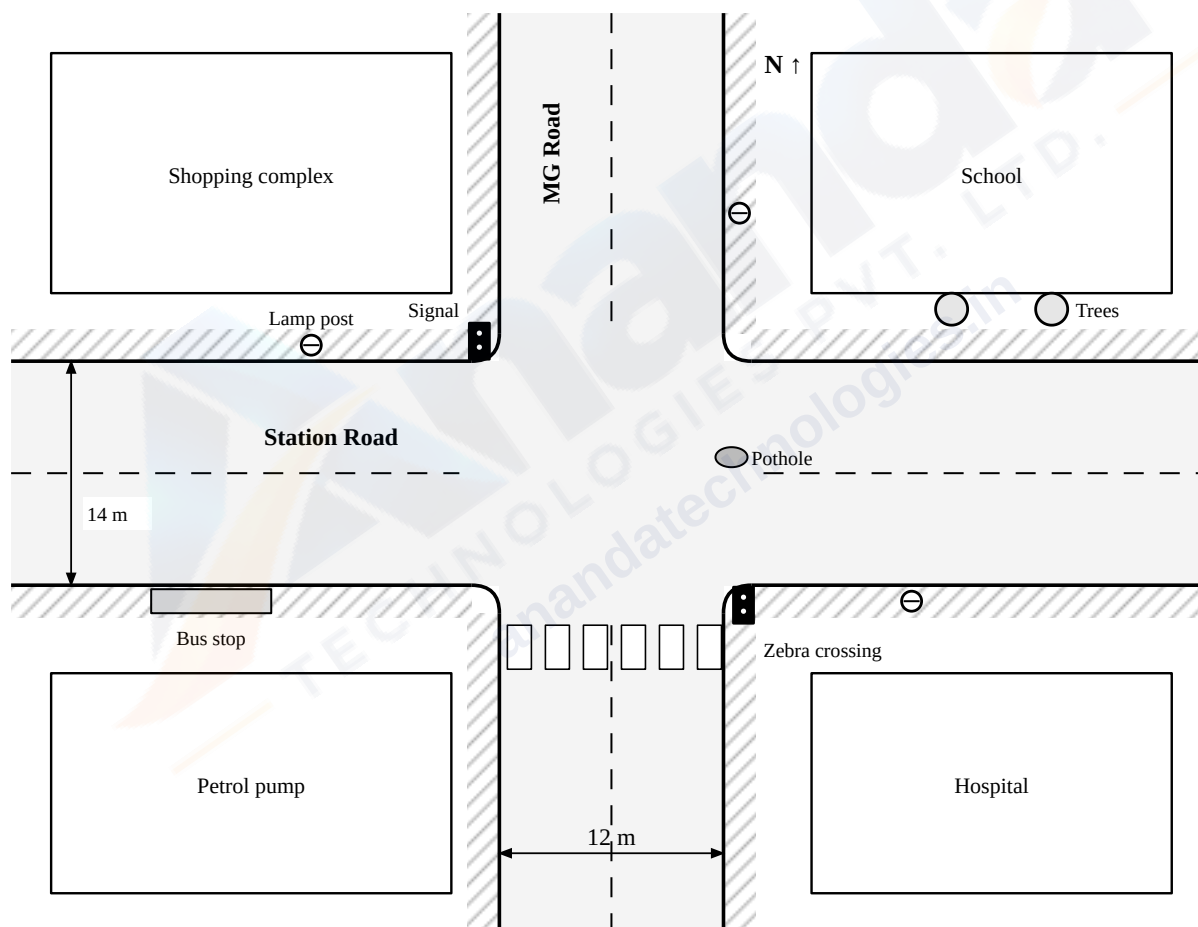


Fig.: Condition diagram of an intersection (sketch; drawn to scale on site)

(Collision diagram with symbols 3 M, condition diagram 3 M)

c) The 3 E's of road accident prevention.

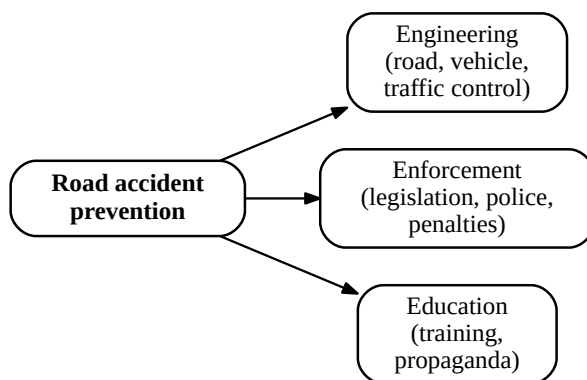


Fig.: The “3 E’s” of road safety

1) Engineering:

- Road engineering — adequate sight distance, super-elevation, widening on curves, skid-resistant surface, channelised intersections, crash barriers, footpaths, street lighting, black-spot treatment.
- Traffic engineering — signs, markings, signals, speed control near schools, one-way streets, parking control.
- Vehicle engineering — good brakes, lights, tyres; ABS, airbags; periodic inspection.

2) Enforcement (with 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.

- 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.

3) Education:

- 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.

(2 M each)

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