Module -3: Traffic Design and Visual Aids: Intersection Design- channelization, Rotary intersection design, Signal design, Coordination of signals, Grade separation, Traffic signs including VMS and road markings, Significant roles of traffic control personnel, Networking pedestrian facilities & cycle tracks.

1. **List four differences between vehicle actuated signal and synchronized signal.**

Vehicle actuated signal	Synchronized signal
➢ Traffic actuated signals are those in which the timings of the phase and cycle are changed according to traffic demand. Vehicle actuated signals, in which the green periods vary and are related to the actual demands made by traffic. ➢ This is made possible by installing detectors on all the traffic. This can be of following types (i) Semi-actuated traffic signals: In semi-actuated traffic signals the normal green phase of an approach may be extended up to a certain period of time for allowing a few more vehicles approaching closely, to clear off the intersection with the help of detectors installed at the approaches. Semi-vehicle-actuated signals, in which the right of way normally rests with the main road and detectors are located only on the side roads. (ii) Fully actuated traffic signal: In fully actuated traffic movements on the basis of demand and pre-determined programming. But these are very costly to be installed at all intersections. (iii) Modern fixed time equipment: Modern fixed time equipment are built for operation with different settings at certain periods of the day, to cover different conditions.	➢ It is also known as simultaneous system. ➢ Under this system, all the signals along a given street always display the same indication to the same traffic stream at the same time. ➢ The division of the cycle time is the same at all intersections. ➢ A master controller is employed to keep the series of signals in step. The disadvantages of a simultaneous system are: (iv) It is not conductive to give continuous movement of all vehicles. (v) The overall speed is often reduced. (vi) Because the division of the cycle time is the same at all the intersections, inefficiency is inevitable at some intersection. (vii) The simultaneous stoppage of a continuous line of traffic at all intersections often results in difficulty for the side street vehicles in turning into or crossing the main side street.

This is achieved by providing time switches	

2. **Explain the importance of channelization in ensuring smooth traffic with neat sketches.**

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

Advantages:

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

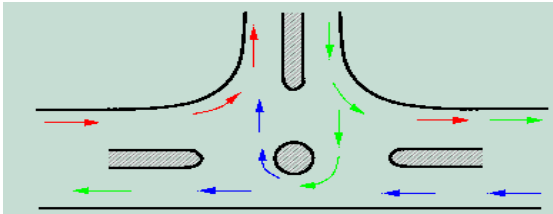


Figure 1: Channelization of traffic through a three-legged intersection

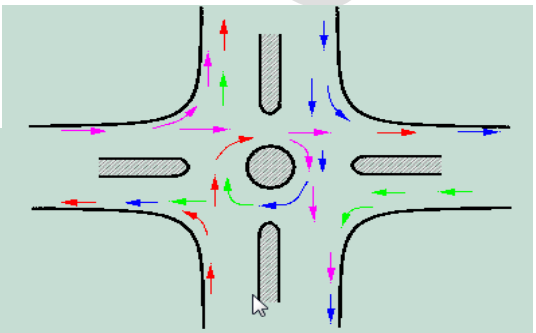


Figure 2: Channelization of traffic through a four-legged intersection

3. **Write short notes on Traffic regulations**

- In order to have safe traffic on roads, it is desirable to impose adequate traffic regulations and traffic control with the help of standard traffic control devices.
- The traffic regulations and control are implemented with the help of suitable regulatory signs, signals, marking, traffic islands and other devices.

The various regulations imposed through the traffic control devices should fulfill the requirements such as:

(i) Clear visibility during the day and night
(ii) Easy to recognize and understand
(iii) Sufficient time for the driver driving at the design speed or within the legal speed limit to react and follow the regulation.
(iv) To ensure safety in general.

Traffic regulations and laws cover the following four phase. –

I. Driver controls
II. Vehicle controls
III. Traffic flow regulations

IV. General controls

Driver controls

- The controls on drivers include eligibility for driving motor vehicles, issue of driving license and other regulations on the drivers during the act of driving.
- As per the Motor Vehicle Act, the minimum age for getting a driving license to drive a non-geared two-wheeler is 16 years and the minimum age for driving a geared two-wheeler or a four wheeler is 18 years.
- Driving a motor vehicle without a valid driving license is an offence.
- Before the issue of driving license for a specified category of vehicle, one has to undergo specified tests.
- The driver is expected to demonstrate his ability to drive the vehicle safely and he should be conversant with the motor vehicle rules and regulations.
- Separate requirements and tests have been specified for driving different categories of motor vehicles such as two-wheeler automobiles, light motor vehicles, public transport vehicles, heavy commercial vehicles, etc.
- There are regulations prohibiting driving under the influence of alcohol or 'drunken driving'.
- Dangerous driving including exceeding the specified speed limits, etc., which may render a driver to pay specified penalty or to suspend the driving license for a specified period or to permanently disqualify from driving a vehicle in the country.
- The Regional Transport Officer has the powers to endorse upon the driving license the particulars of the traffic violations and when the number and severity of the violations exceed the permissible limit, the license can be suspended or even cancelled.

Vehicle controls

- Regulations and controls on vehicles include vehicle registration, requirements of equipment and accessories of motor vehicles, maximum permissible dimensions and weight, vehicle fitness, inspections, etc.
- The registration is essential for any new motor vehicle.
- The information about the details of the vehicle such as the type, make, capacity of engine, manufacture's serial number, details of the owner, license plate number, etc. are registered in the transport department and police records.
- There are different specifications for public transport vehicles, hired vehicles and private vehicles for displaying the registration number.
- For example private vehicles have to display the registration numbers of specified size letters and numerals written in black colour on plate with white back-ground.
- The specified colour of the registration plate is yellow for public transport vehicles including hired vehicles.
- The regulation covers the length, width, height, type and condition of tyres, maximum weights of commercial vehicles seating arrangements and number of

seats in public service vehicles, lamps and signaling appliances, emission, noise, use of horn, speed governors , safety glasses, etc.

- At least a third party insurance policy is mandatory for all vehicles.

General regulations and provisions

- They include reporting of accidents, recording and disposing traffic violation cases, etc.

Traffic flow regulations

- One-way regulation
- Turning restrictions at junctions
- Various other regulations such as Stop, Speed limit, Restrictions on overtaking, parking, stopping, etc. are implemented by appropriate regulatory signs.

Implementation of regulations

- The traffic regulations have been enacted and implemented in India with the help of the Motor Vehicle Act of 1939, The revised Motor Vehicle Act of 1988.
- These have covered various traffic regulatory measures in three major phases, namely control on the drivers, vehicle ownership and vehicle operation on roads and in traffic stream.
- The various items covered are issue of driving license, registration of vehicles, transfer of ownerships, distinction between private and public vehicles, transport authorities and inter-state commission, limits of speed, weight, restrictions on parking and halting places, vehicle insurance and fees, signs, signals and general provisions for punishment of violations and offences.

4. Write short notes on Signal coordination

Signal coordination is done when signals are closely spaced to enable vehicle in one predominant direction to get continuous green. This will reduce the delay and travel time in one direction and increases traffic flow.

Objectives:

- Reduce queue length
- Minimum overall delay to traffic streams
- Pass the maximum amount of traffic

Types:

1. Simultaneous system
2. Alternate system
3. Simple progressive system
4. Flexible progressive system

Simultaneous system

- All the signals along a given street will display the same indication to the same traffic stream at the same time.
- Division of cycle time is same at all intersections
- A master controller is employed to keep the series of signals in step.

Disadvantages:

- It's not conducive to give continuous movement of all vehicles
- It encourages speeding of drivers between stops
- Since division of cycle time is same at all intersections, inefficiency is inevitable at some intersection
- Simultaneous stopping of vehicles at all intersection cause difficulty for the side street vehicles while turning.

Alternate system

- Consecutive traffic signal installations along a given road show contrary indications at the same time. This permits the vehicles to travel one block in one half of the cycle time.
- It brings about a certain measure of speed control since speeding drivers are stopped at each signal.

Disadvantages:

- Green times for both major and minor streets have to substantially equal. Hence, more wastage of time.
- If the block length is not equal, it's not well suited.
- Adjustments are difficult for changing traffic conditions.

Simple Progressive system

- Various signals along a street display green aspects in accordance with a time schedule to permit, as nearly as possible continuous operation of vehicles at a planned rate of motion.
- The offset period is so selected that there are minimum delays. But the offset is fixed throughout the day.

Flexible progressive system

- Cycle time and division at each signal is dependent upon the traffic.
- It remains flashing or shut down during off peak hours
- It's possible to vary offset.

5. The average normal traffic on cross roads A and B during the design period is 425 and 185 PCV/hr. Saturation flow values estimated are 850 and 720 PCV/hr respectively. All red time for pedestrian crossing is 12 sec. Design a two phase traffic signal by Webster's method.

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

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

yA = 425/850 = 0.5

yB = 185/720 = 0.26

y = 0.5+0.26 = 0.76

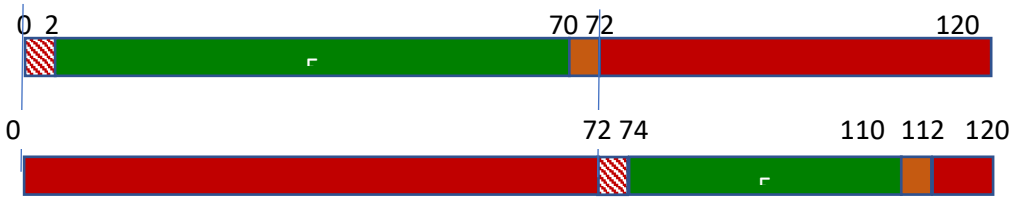
C0 = Optimum cycle time = $1.5L+5/(1-y)=1.5\times16+5/(1-0.76)$ = 121 sec.

Restrict the cycle time to 120 s as per the codal provsions

Effective green time = 120-16= 104 sec

Effective green time for A = 0.5/0.76×104=68 sec

Effective green time for B = 0.26/0.76×104=36 sec



6. Outline the causes of accidents and suggest remedial measures for prevention.

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.

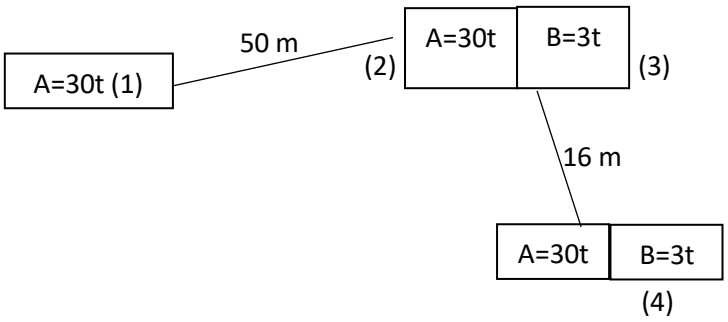
Education of road users:

- 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

7. **A vehicle of weight 30 tonnes skids through a distance equal to 50 m, before colliding with another parked vehicle of weight 3 tonnes. After collision, both the vehicles skid through a distance equal to 16 m, before stopping. Determine the speeds of vehicles assuming f-0.4 (i) after collision (ii) at collision (iii) before collision.**



After collision (path 3-4):

$u = v_{A3}$

$v = 0$

$v^2 = u^2 + 2aS$

$0 = (v_{A3})^2 - 2\times0.5\times9.81\times16$

$v_{A3} = 12.53$ m/s

At collision (path 2-3):

Principle of conservation of momentum

$WA\times v_{A2} + WB\times 0 = (WA + WB)\times v_{A3}$

$30\times v_{A2} + 3\times 0 = (33)\times 12.53$

$v_{A2} = 13.78$ m/s

Before collision (path 1-2):

$u = v_{A1}$

$v = v_{A2}$

$v^2 = u^2 + 2aS$

$13.78^2 = (v_{A1})^2 - 2\times0.5\times9.81\times50$

v_{A1} = 26.08 m/s

8. **Advantages and dis advantages of traffic signals**

Advantages of traffic signals

- Provide orderly movement of traffic at the intersection.
- The quality of traffic flow is improved by forming compact platoons of vehicles, provided all the vehicles move at approximately the same speed.
- Reduction in accidents due to crossing conflict, notably the right angled collisions.
- Traffic handling capacity is highest among the different types of intersections at-grade.
- Provide a chance to traffic of minor road to cross the continuous traffic flow of the main road at reasonable intervals of time.
- Pedestrians can cross the roads safely at the signalized intersection.

- When the signal system is properly co-ordinate, there is a reasonable speed along the major road traffic.
- Automatic traffic signal may work out to be more economical when compared to manual control.

Disadvantages of traffic signals

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

9. Highlight the functions of different types of signals.

- To allow for orderly movement of traffic at the intersection.
- To improve the quality of traffic flow by forming compact platoons of vehicles, provided all the vehicles move at approximately the same speed.
- To reduce accidents especially the right angled collisions.
- Traffic handling capacity is highest among the different types of intersections at-grade.
- Provide a chance to traffic of minor road to cross the continuous traffic flow of the main road at reasonable intervals of time.
- To help pedestrians to cross the roads safely at the signalized intersection.
- To maintain a reasonable speed along the major road traffic.

10. Describe Webster method of signal design

Webster's method of traffic signal design is an analytical approach of determining the optimum signal cycle time, corresponding to minimum total delay to all the vehicles at the approach roads of the intersection.

DESIGN STEPS:

Step 1: Calculate Y

$Y = y1+y2\ldots$

Where y = design flow/ saturation flow

Step 2: Calculate total lost time

Total lost time = $\Sigma l + \Sigma(i-a)$ or Σl + All red time

Where, l : starting delay per phase

i= inter green period

a= amber period

(If not provided in question, consider i = 4 seconds and a= 2 seconds

Step 3: Calculate optimum cycle length

C_0 is always restricted to 120 sec

$$C_0 = \frac{1.5\,L + 5}{1 - Y_i}$$

Step 4: Calculate green time for the phases;

Co-L : Effective green time

$$G_1 = \frac{y_1}{Y}(C_o - L), \text{and } G_2 = \frac{y_2}{Y}(C_o - L)$$

11. Mention different types of traffic signals.

The signals are classified into the following types ***based on the purpose***

1. Traffic control signals
2 .Pedestrian signal
3. Special traffic signal

1. ***Traffic control signal:*** The traffic control signals have three coloured lights which glow facing each direction of traffic flow namely, red, amber and green.
   - The red light is meant for 'stop',
   - The green light for 'go' and
   - The amber or yellow light allows the 'clearance time' for the vehicles which enter the intersection area by the end of green time to clear off the intersection, before the change-over to red signal light.
   - Additional signals showing green lights for separate movements of turning traffic movements may also be provided, where necessary.

2. ***Pedestrian signals:*** Pedestrian signals may be installed at the intersections controlled by traffic signals to enable the pedestrians to safely cross the specified roads; In such cases, the pedestrian signals and their timings are interlinked to operate along with the traffic control signal. At certain locations of mid-block stretches of urban roads with high demand for pedestrian crossing, separate pedestrian signals may be installed along with appropriate warning and informatory signs.
3. ***Special traffic signals:*** Special traffic signals such as 'flashing beacons' may be installed at certain locations in order to warn the traffic of certain situations. At flashing red signals, the drivers of vehicles shall stop before entering the nearest cross walk at an intersection or at a stop line. Flashing yellow signals are cautionary signals meant to signify that drivers may proceed with caution.

Based on operation, different traffic signals are operated are classified as

(i) Manually operated signals
(ii) Fixed time automatic signals and
(iii) Automatic traffic-actuated signals.

Manually operated signals

Each of manually signals is operated from a salient point at or near the intersection by a traffic police constable; the signal phases may be varied depending on the traffic demand at that point of time.

Fixed time automatic signals:

The fixed time automatic traffic signal keeps repeating the same set of signal phases and the signal cycle time that has been set in the signal controller.

This type of traffic signal may function satisfactorily at locations where there is no significant variation in traffic flow on different approach roads.

The timing of each phase of the cycle is predetermined based on the traffic studies and they are the simplest and cheapest type of automatic traffic signals which are electrically operated.

The main drawback is that when the traffic flow on one road may be almost nil and traffic on the cross road may be quite heavy, yet the traffic in the heavy stream will have to keep waiting at red phase.

Automatic traffic- actuated signals:

Traffic actuated signals are those in which the timings of the phase and cycle are changed according to traffic demand.

Vehicle actuated signals, in which the green periods vary and are related to the actual demands made by traffic.

This is made possible by installing detectors on all the traffic.

Vehicle-actuated signals can be of the following types

a) Semi-actuated traffic signals: In semi-actuated traffic signals the normal green phase of an approach may be extended up to a certain period of time for allowing a few more vehicles approaching closely, to clear off the intersection with the help of detectors installed at the approaches. Semi-vehicle-actuated signals, in which the right of way normally rests with the main road and detectors are located only on the side roads.

b) Fully actuated traffic signal In fully actuated traffic movements on the basis of demand and pre-determined programming. But these are very costly to be installed at all intersections.

c) Modern fixed time equipment: Modern fixed time equipment are built for operation with different settings at certain periods of the day, to cover different conditions. This is achieved by providing time switches

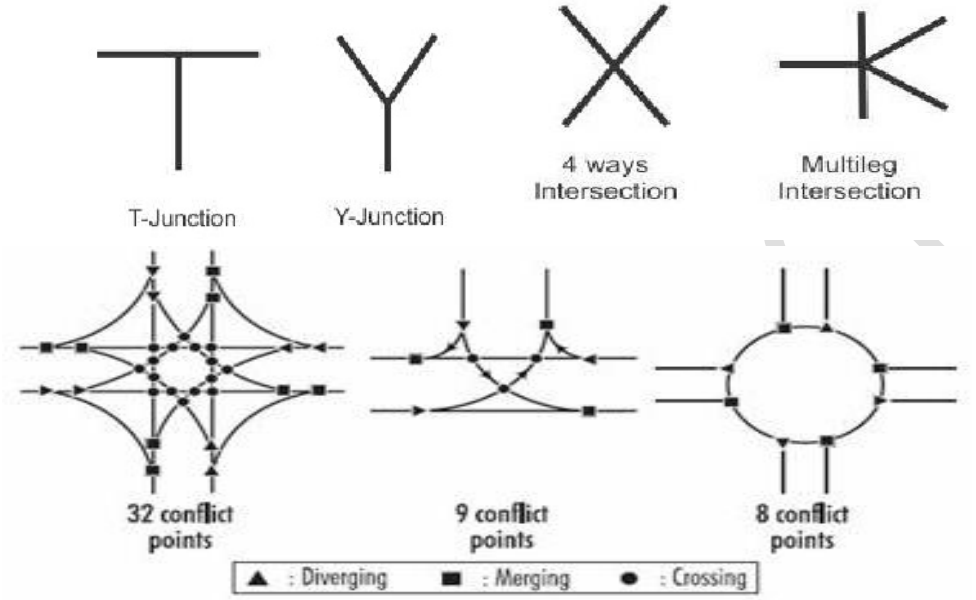
12. Describe the different types of at grade intersections.

An intersection is the area shared by the joining or crossing of two or more roads.

Requirements for good intersection design

- Number of intersections should be minimum.
- Geometric layout should be such that hazardous movements are eliminated.

- Design should permit the driver to discern quickly from the layout or from the traffic signs, the path he should follow and the actions of merging and diverging.
- Conflicting points should be minimum.
- Traffic path should be smooth without abrupt and sharp corners.
- Crossing traffic should be given adequate waiting space.



Levels of intersection control

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

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

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

- ✓ Channelization:
- ✓ Traffic rotaries

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

- ✓ Traffic signals
- ✓ Grade separated intersections

13. Describe 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.

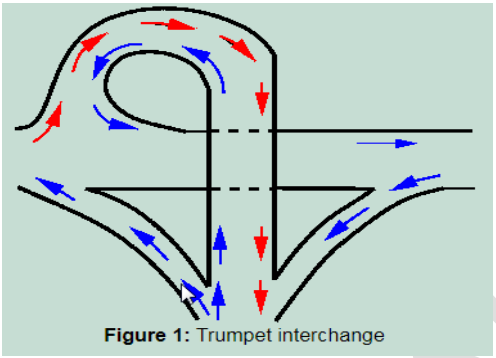


Figure 1: Trumpet interchange

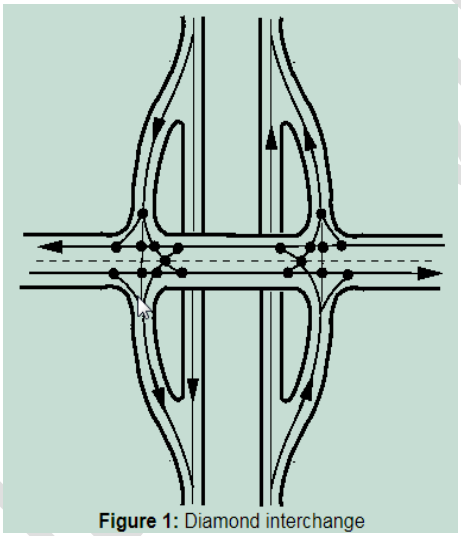


Figure 1: Diamond interchange

- 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:

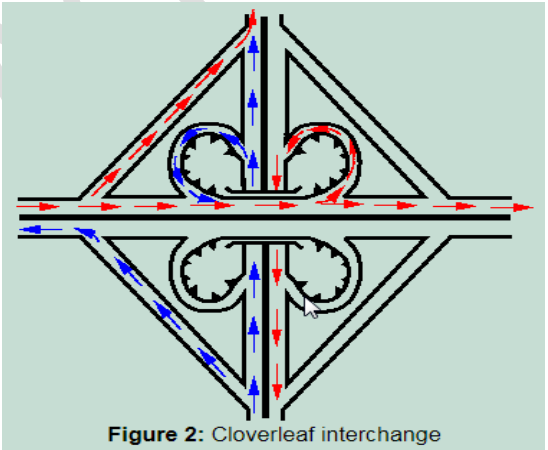
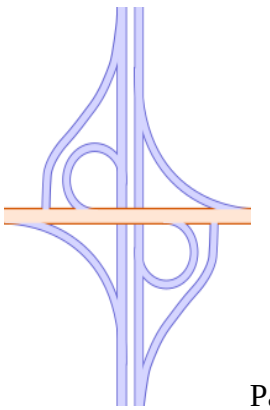


Figure 2: Cloverleaf interchange



Partial Clover leaf

14. Describe the advantages and disadvantages of traffic rotary.

Advantages of rotary intersection

- Traffic flow is regulated to only one direction of movement, thus eliminating severe conflicts between crossing movements.
- All the vehicles entering the rotary are gently forced to reduce the speed and continue to move at slower speed. Thus, none of the vehicles need to be stopped, unlike in a signalized intersection.
- Because of lower speed of negotiation and elimination of severe conflicts, accidents and their severity are much less in rotaries.
- Rotaries are self governing and do not need practically any control by police or traffic signals.
- They are ideally suited for moderate traffic, especially with irregular geometry, or intersections with more than three or four approaches.

Limitations of rotary intersection

- All the vehicles are forced to slow down and negotiate the intersection. Therefore, the cumulative delay will be much higher than channelized intersection.
- Even when there is relatively low traffic, the vehicles are forced to reduce their speed.
- Rotaries require large area of relatively flat land making them costly at urban areas.
- The vehicles do not usually stop at a rotary. They accelerate and exit the rotary at relatively high speed. Therefore, they are not suitable when there is high pedestrian movements.

15. What is a rotary intersection? Describe the different traffic movement in a rotary.

Rotary intersections or roundabouts are special form of at-grade intersections laid out for the movement of traffic in one direction around a central traffic island.

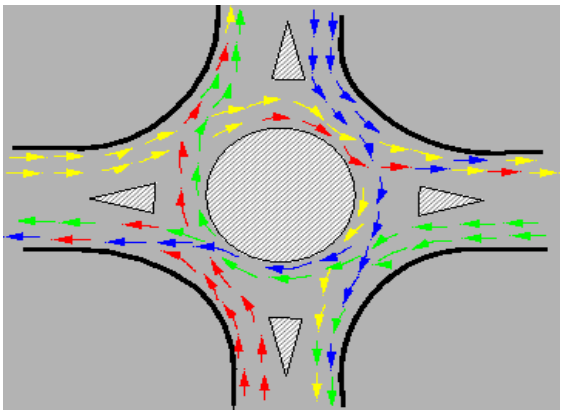
Through and right-turn movements are converted into milder conflicts namely merging and diverging

Traffic operations in a rotary

Diverging: It is a traffic operation when the vehicles moving in one direction is separated into different streams according to their destinations.

Merging: Merging is the opposite of diverging. Merging is referred to as the process of joining the traffic coming from different approaches and going to a common destination into a single stream.

Weaving: Weaving is the combined movement of both merging and diverging movements in the same direction.



Guidelines for the selection of rotary intersection

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

16. Classify the different types of traffic signs. Explain with neat sketches.

Traffic signs

- Traffic signs and road markings are silent speakers to the road users
- They give advance information about road conditions ahead.
- Road markings also give orders, warning or guidance to drivers or riders
- It increases safety in road transport

Types of Traffic signs

1. Mandatory Signs
2. Cautionary Signs / Warning
3. Informatory Signs

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 war 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 borer and black symbols

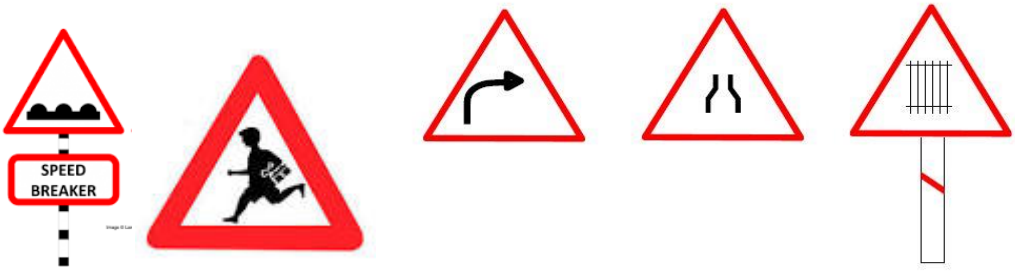


Figure: speed breaker, school, Right hand curve sign board, signs for narrow road, sign indicating railway track ahead)

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

17. Explain the advantages and disadvantages of traffic signs

Advantages of traffic signs:

- Traffic signs and road markings are silent speakers to the road users.
- They give **advance information** about road conditions ahead.
- Road markings also give orders, warning or guidance to drivers or riders.
- It increases **safety** in road transport

- The traffic signs command attention from the road users
- Traffic signs are designed in such a way that it provides **clear, simple meaning**
- The control devices and traffic sign **provide adequate** time for proper response from the road users

Disadvantages

- Increase in Rear-End Collisions.
- Excessive Traffic Delays
- Aggressive, Impatient Driving
- Cost incurred

18. Discuss briefly, fixed signal and vehicle actuated signals.

Fixed time signal/ Pre-timed signals

- Simplest automatic traffic signal
- Repeat the signal lights (Red, Green and amber) regularly or on predetermined basis.
- The major disadvantage is that the timings are not sensitive to traffic flow. So it cannot be used successfully for intersections with major and minor roads having different traffic intensities.

Vehicle actuated signals:

- Here signal timings are altered based on traffic demand.
- This can be (i) Semi-actuated or (ii) Fully actuated
- In semi actuated traffic signal the normal green period of any phase can be extended for some more time based on the traffic volume. Detectors are installed at selected approaches for the intersection
- In fully actuated signals detectors are connected to all approaches and they are synchronized so that the signal timings gets automatically readjusted based on the traffic. But it is costly to be provided in all intersections.

19. The average normal flow of traffic on cross roads A and B during design periodsare 400 and 250 PCU/hr. The saturation flow values on these roads are estimated as1250 and 1000 PCU/hr respectively. The all red time for pedestrian crossing is 12 sec. Design a two phase traffic signal bt Webster's method and draw the phase diagram.

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

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

yA = 400/1250 = 0.32

yB = 250/1000 = 0.25

y = 0.32+0.25 = 0.57

C0 = Optimum cycle time = $1.5L+5/(1-y)=1.5\times16+51-0.57 = 67.44$ sec = 68 sec.

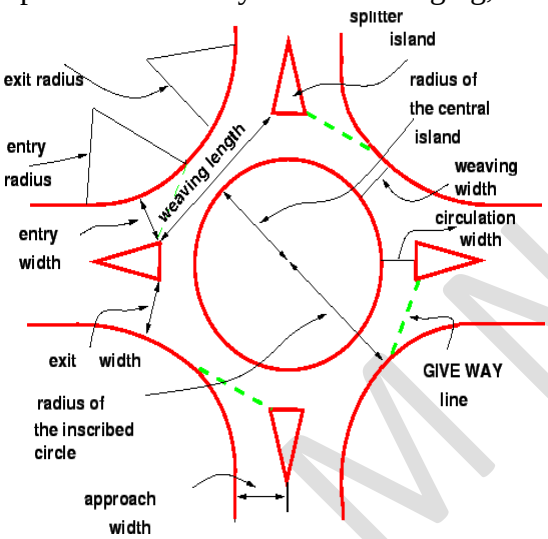
Effective green time = 68-16= 52 sec

Effective green time for A = 0.32/0.57×52=29 sec

Effective green time for B = 0.25/0.57×52=23 sec

20. What is rotary? Explain the important design elements of a rotary with the help of relevant sketches.

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



There are 6 design elements of rotary intersection

1)Design speed

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

2)Entry, exit and island radius

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

3)Entry and exit width:

- The width of the road at entry and exit will be **lower** than the width of the road at the approaches to enable reduction of speed.
- IRC suggests that a **two lane road of 7 m width should be kept as 7 m** for urban roads and **6.5 m for rural roads**.
- Further, a three lane road of **10.5 m is to be reduced to 7 m** and **7.5 m** respectively for urban and rural roads.

4)Weaving width (w)

- The width of the weaving section should be higher than the width at entry (e_1)and exit(e_2)

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

.

5)Weaving length (l):

- It is decided based on many factors such as **weaving width, proportion of weaving traffic to the non-weaving traffic** etc
- This can be best achieved by making the **ratio of weaving length to the weaving width very high.**
- A ratio of **4 is the minimum** value suggested by IRC.
- Very large weaving length is also dangerous, as it may encourage speed

6) Capacity (Q_w)

The capacity of rotary is determined by the capacity of each weaving section by using the following empirical formula, where p is the proportion of weaving traffic.

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

21. Explain VMS.

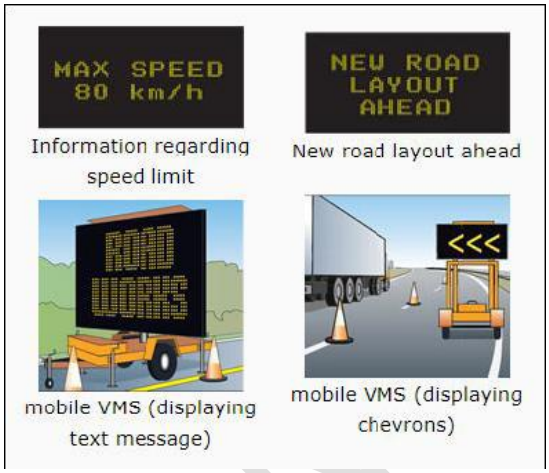
Variable message signs (VMS) is an electronic traffic sign often used on roadways to give travellers information about special events. The information comes from a variety of traffic monitoring and surveillance systems. The content of the sign will change, dependent on the situation.

Advantages:

- It provides real-time information on special events on the oncoming road
- It improves motorists' route selection, reduce travel time, mitigate the severity and duration of incidents and improve the performance of the transportation network.
- It warns driver of traffic congestion, accidents, incidents, roadwork zones, or speed limits on a specific highway segment.

- In urban areas, VMS provides parking guidance and information systems to guide drivers to available car parking spaces.
- It helps vehicles to take alternative routes, limit travel speed, warn of duration and location of the incidents or just inform of the traffic conditions.

Truck-mounted VMS (also called Portable Changeable Message Signs or PCMS) are sometimes dispatched by highway agencies to warn traffic of incidents such as accidents in areas where permanent VMS aren't available or near enough as a preventive measure for reducing secondary accidents.



22. What are the types of different types of road markings? Explain with neat sketches.

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

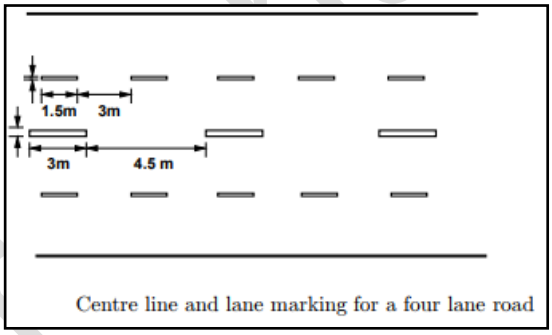
- No passing zones are established on summit curves, horizontal curves, and on two lane and three lane where overtaking maneuvers are prohibited because of low sight distance.
- It may be marked by a solid yellow line along the centre or a double yellow line.

Warning lines

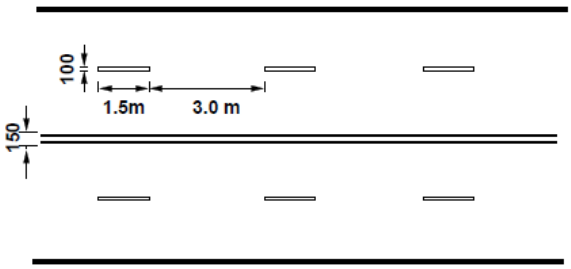
- Warning lines warn the drivers about the obstruction approaches.
- They are marked on horizontal and vertical curves where the visibility is greater than prohibitory criteria specified for no overtaking zones.
- They are broken lines with 6 m length and 3 m gap.

Edge lines

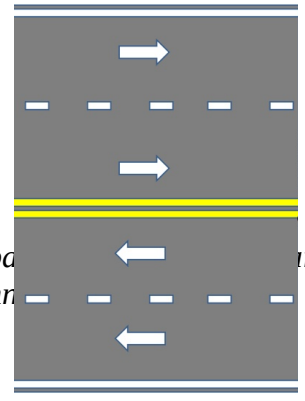
- Edge lines indicate edges of rural roads which have no kerbs to delineate the limits upto which the driver can safely venture.
- They should be at least 150 mm from the actual edge of the pavement.
- They are painted in yellow or white.

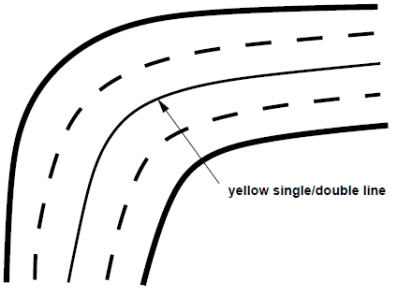


Centre line and lane marking for a four lane road

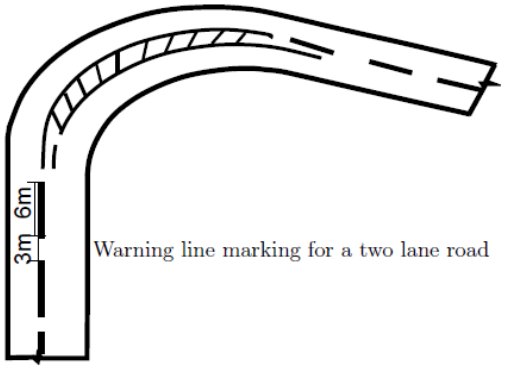


Lane marking for a four lane road with solid barrier line

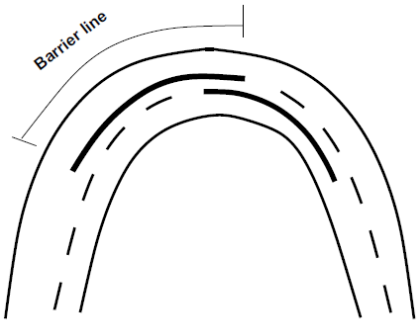




Barrier line marking for a four lane road



Warning line marking for a two lane road



No passing zone marking at horizontal curves

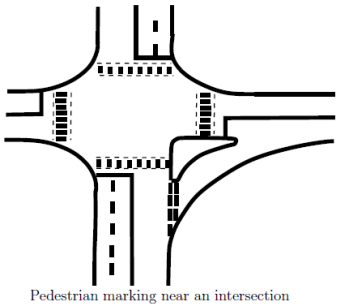
Transverse markings

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.

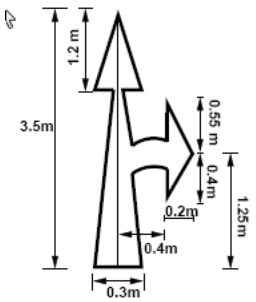
Pedestrian crossings

- 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.

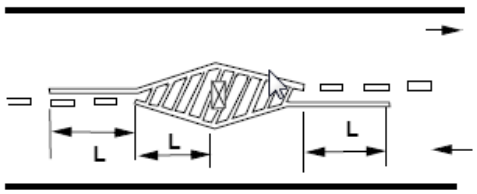
Word messages

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.



23. With a neat sketch, indicate various elements of traffic rotary.

Same as Answer to 21.

24. Explain with neat sketches, condition and collision diagram.

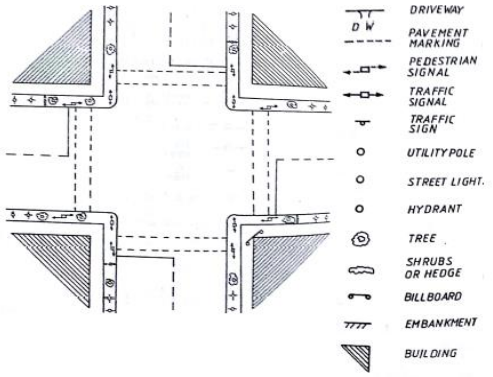
Condition Diagram:

- 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

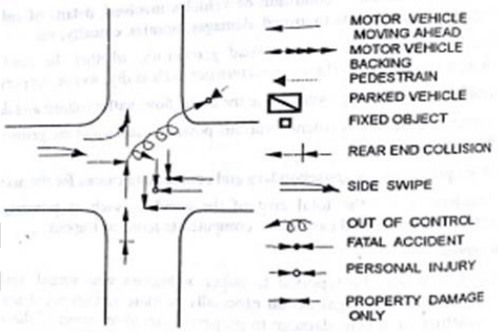
Collision diagram:

- 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.

Condition diagram



Collision diagram



25. Explain the various preventive measures to reduce accidents.

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

<u>Safety measures related to engineering</u>

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.

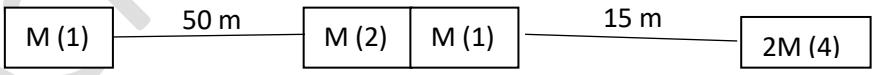
Education of road users:

- 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

26. A vehicle skids through a distance of 50 m before colliding with another parked vehicle. After collision both vehicles skid through a distance equal to 15 m, before stopping. If weights of both the vehicles are equal, compute the critical speed of moving vehicle. Assume coefficient of friction as 0.40.



After collision (path 3-4):

$u = v_{A3}$

$v = 0$

$v^2 = u^2 + 2aS$

$0 = (v_{A3})^2 - 2\times0.4\times9.81\times15$

$v_{A3} = 10.85$ m/s

At collision (path 2-3):

Principle of conservation of momentum

$WA\times v_{A2} + WB\times 0 = (WA + WB)\times v_{A3}$

$M\times v_{A2} + M\times 0 = (2M)\times 10.85$

v_{A2} =21.7 m/s

Before collision (path 1-2):

u = v_{A1}

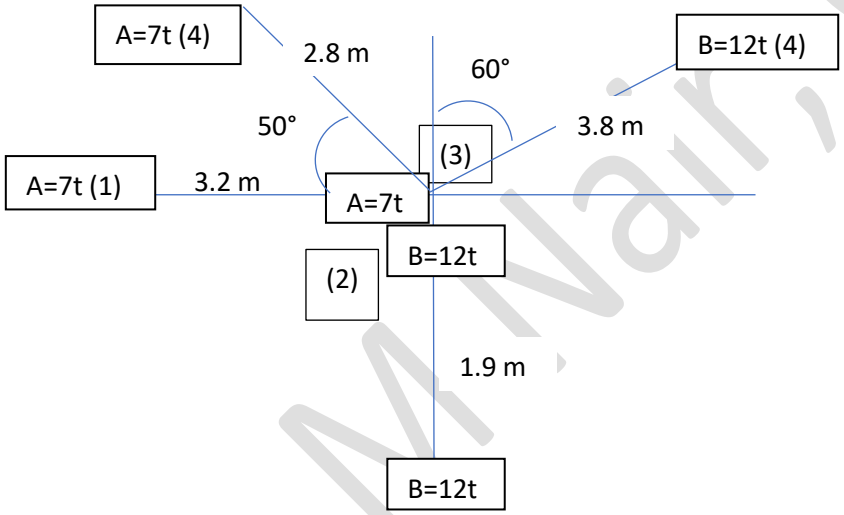
v = v_{A2}

$v^2 = u^2 + 2aS$

$21.7^2 = (v_{A1})^2 - 2\times0.4\times9.81\times50$

v_{A1} = 29.38 m/s

27. Two trucks A and B of gross weight 7T and 12T approaching from right angles applied brakes and skid through distances 3.2 m and 1.9 m respectively before collision. After collision truck A was thrown back making an angle of 50° with its original direction and skid through a distance of 2.8 m. truck B skid along a distance of 3.8 m deviating at an angle of 60° from its original path. Estimate the initial speeds of approach of the two trucks.



After collision (path 3-4):

u = v_{A3}

v = 0

$v^2 = u^2 + 2aS$

$0 = (v_{A3})^2 - 2\times0.5\times9.81\times2.8$

v_{A3} =5.24 m/s

u = v_{B3}

v = 0

$v^2 = u^2 + 2aS$

$0 = (v_{B3})^2 - 2\times0.5\times9.81\times3.8$

V_{B3} =4.32m/s

At collision (path 2-3):

Principle of conservation of momentum

Resolving forces horizontally

$7v_{A2}+0 = 7\ v_{A3}\ Cos45 + 12\ Sin\ 45$

$7v_{A2}+0 = 7 \times 5.24 \times \text{Cos}50 + 12 \text{ Sin } 60 \times 4.32$

$v_{A2} = 9.78$ m/s

Resolving forces vertically

$12v_{B2}+0 = -7 \times 5.24 \times \text{Sin}50 + 12 \text{ Cos } 60 \times 4.32$

$V_{B2} = 4.5$ m/s

Before collision (path 1-2):

$u = v_{A1}$

$v = v_{A2}$

$v^2 = u^2 + 2aS$

$9.78^2 = (v_{A1})^2 - 2 \times 0.5 \times 9.81 \times 3.2$

$v_{A1} = 11.27$ m/s

$u = v_{B1}$

$v = v_{B2}$

$v^2 = u^2 + 2aS$

$4.5^2 = (v_{B1})^2 - 2 \times 0.5 \times 9.81 \times 1.9$

$V_{B1} = 6.24$ m/s

28. A vehicle of weight 3000 kg skids through 50 m before colliding with a parked vehicle of weight 1250 kg. After collision, both the vehicles skid through 18 m before coming to a halt. Assuming coefficient of friction as 0.5, explain the steps and calculate:

(i) Speed after collision

(ii) Speed at collision

(iii) Speed at which heavier vehicle was moving initially

Similar to earlier problem