



WINTER-19 EXAMINATION

MODEL ANSWER

22302**Subject: Highway Engineering****Subject Code-**

- 1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
- 2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
- 3) The language errors such as grammatical, spelling errors etc... should not be given more Importance (Not applicable for subject English and Communication Skills).
- 4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
- 5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
- 6) In case of some questions credit may be given by judgment on part of examiner of relevant answer based on candidate's understanding.
- 7) For programming language papers, credit may be given to any other program based on equivalent concept.

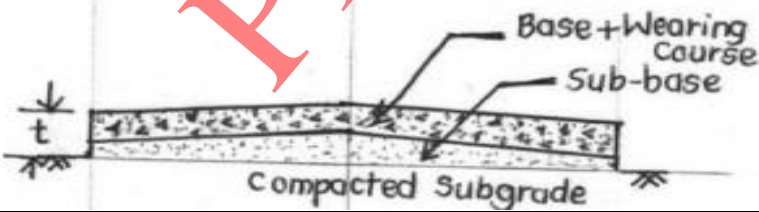
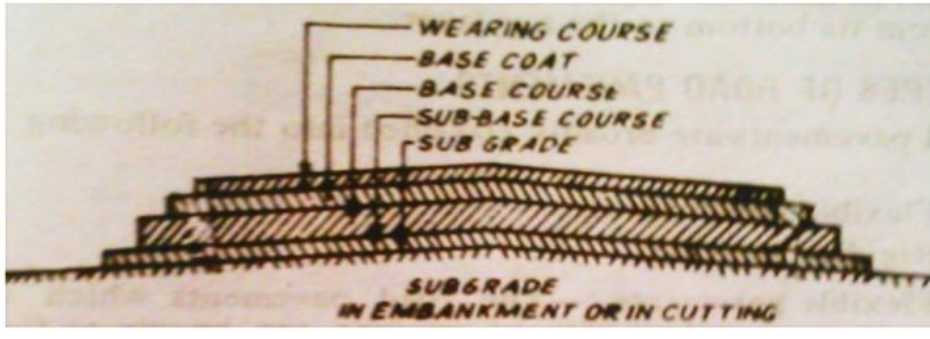
Que. No.	Sub Que.	Answer	Marking Scheme	Total Marks
1		Solve any FIVE:		10
	a) Ans.	State any four modes of transportation Four modes of transportation are: a) Roadways or Highways b) Railways c) Waterways d) Airways.	1/2 mark each	2
	b) Ans.	Classify the roads according to Nagpur Road Development plan. According to Nagpur plan, roads are classified as: 1) National Highway (NH) 2) State Highway (SH) 3) Major District Road (MDR) 4) Other District Road (ODR) 5) Village Road (VR)	2	2
	c) Ans.	State any two requirements of a Ideal road alignment a) Crossing: The provision of railway and road crossing should be properly studied. Dangerous road and rail crossing should be avoided. b) Proper drainage: The provision of proper and sufficient drainage is necessary for the stability of the road and hence the road alignment should take into consideration factors like rain water, ground water etc... c) Availability of local materials: For reducing the cost of construction and maintenance, it is necessary to have easy availability of natural materials like sand, gravel, soil etc...	2 marks (any two)	2







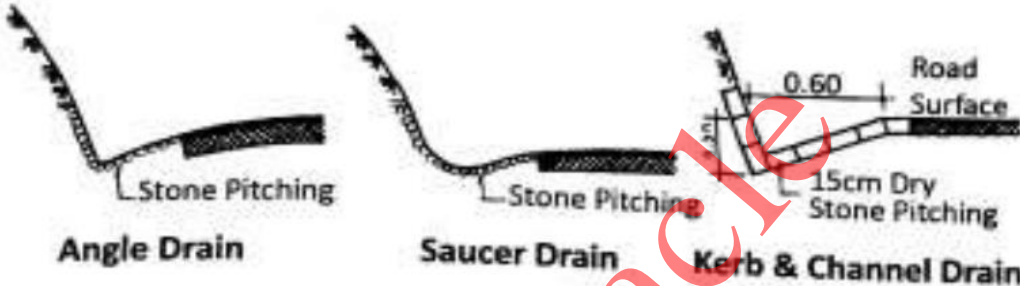
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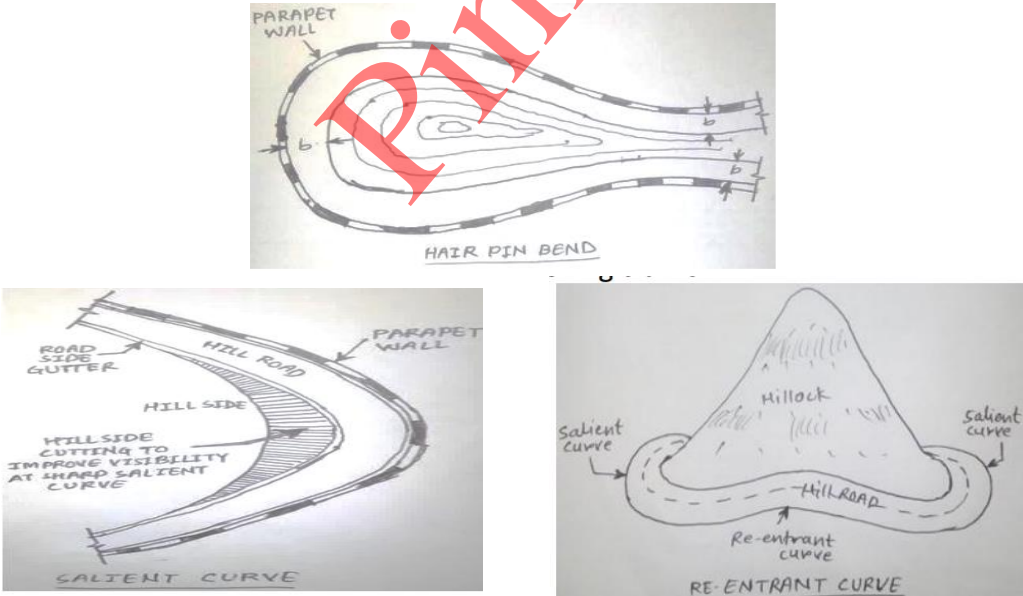
1	<p>d) The road should have good visibility at night and other climatic conditions e) The alignment should be such that sufficient safety should be there while travelling on the road f) The road should connect important points like school, places of tourist's importance etc... g) The road should be such that the slope and curves are easy. h) It is desirable to have short distance between the two terminal stations. i) It should provide economy in the cost of construction and maintenance. j) The alignment should be safe for traffic operation. k) The alignment should provide maximum utility by connecting important towns and group of villages. l) The alignment should pass through regions of natural beauty and scenery to have good natural aspects</p>		
	<p>d) Define traffic volume and traffic density Ans. Traffic Volume: It is the number of vehicles moving in a specified direction on a given lane or roadway that pass a given point or cross section during specified unit of time Traffic Density: It is the number of vehicles occupying a unit length of lane of roadway at a given instant usually expressed as vehicles per km.</p>	1 1	2
	<p>e) Enlist any four types of traffic islands Ans. a) Divisional Island. b) Pedestrians Loading Islands c) Channelized Intersections d) Roundabouts or Rotaries</p>	½ mark each	2
	<p>f) State any two causes of landslides Ans. Causes of Landslides: a) Increase in the water content of the soil b) Improper drainage system c) Increase in the weight due to accumulation of snow and external loads due to traffic d) Undermining caused by erosion or extraction e) Vibration and shocks caused by blasting or earthquakes f) Hair cracking due to alternate swelling and shrinkage of the soil mass g) Formation of faults in bedding planes of strata due to vibrations. h) Due to seepage pressure of percolating ground water i) Due to failure of breast wall</p>	1 mark each (Any two)	2
	<p>g) State the types of drainage system Ans. In plain areas, a) Surface Drainage b) Sub-surface Drainage Surface Drainage: Side drains, Catch water basin, Inlet Sub surface: Cross Drains, lateral drain, longitudinal drain, transverse drain OR In Hilly areas, a) Surface Drainage b) Sub-surface Drainage a) Surface Drainage: Side drains, catch water drain b) Sub surface drainage: Cross drains</p>	2 OR 2	4

2	Solve any THREE :		12
	<p>a) Define gradient and state any four types of gradient. Ans. The rate of rise and fall along the length of road w.r.t. horizontal surface is called as Gradient.</p> <p style="text-align: center;">OR</p> <p>The longitudinal slope provided along the length of road, is known as Gradient.</p> <p>Types 1) Ruling gradient 2) Limiting gradient 3) Exceptional gradient 4) Average gradient 5) Floating gradient 6) Minimum gradient</p>	2	4
	<p>b) Define i) Stopping Sight distance ii) Overtaking sight distance i) Stopping Sight Distance: SSD may be defined as the length of highway required to bring a vehicle to stop at various design speeds when the eye of the driver is 1200mm above the pavement and the object causing the stop is 150mm above the pavement.</p> <p style="text-align: center;">Or</p> <p>The driver of the vehicle should be able to see clearly at least a certain portion of the road length to avoid collision or accident. This absolute minimum length required for this purpose is known as Stopping Sight Distance</p> <p>ii) Overtaking Sight Distance: OSD may be defined as the minimum distance open to the vision of the driver of a vehicle intending to overtake the slow vehicle ahead safely against the traffic in the opposite direction.</p>	1	4
2	<p>c) Draw a neat sketch of std. C/s of National Highway in embankment. Ans. Cross-section of National Highway in Embankment:</p> <p style="text-align: center;">CROSS-SECTION OF A NATIONAL HIGHWAY (NH) IN EMBANKMENT</p>	2 marks for sketch 2 marks for labeling	4

	<p>d) State any two merits and demerits of WBM road. Ans. Merits of WBM roads: 1) If in good condition, it can take a composite traffic of about 900 tonnes per lane per day 2) If WBM surfacing is maintained properly, it is found to have good service for a long-time. 3) Their initial cost is low. 4) They make use of the locally available materials. Demerits of WBM: 1) The maintenance cost is more. 2) If not maintained properly, then it causes inconvenience and danger to traffic. 3) They are permeable to rain water and it leads to the softening and yielding of materials 4) Life is less</p>	<p>2 (Any two)</p> <p>2 (Any two)</p>	<p>4</p>
<p>3</p>	<p>Solve any THREE:</p>		<p>12</p>
<p>a) Ans.</p>	<p>Write the procedure of construction of cement concrete pavement showing its components. Construction procedure of Concrete Roads: 1) Preparation of subgrade by proper compaction 2) Provision of sub base to support subgrade 3) Placing of forms i.e. Steel channels 4) Batching and mixing of materials in plant 5) Transportation and placing of concrete through RMC vehicle 6) Compaction of poured concrete using vibrators 7) Floating of concrete using steel beam 8) Brooming of concrete surface using steel brush 9) Edging of concrete for obtaining sharp edges 10) Curing of road surface by ponding method 11) Filling of joints using joint sealers 12) Opening of traffic after cleaning</p> 	<p>3</p> <p>1</p>	<p>4</p>
	<p>b) Draw C/S of typical flexible pavement & label its components</p> 	<p>4</p>	<p>4</p>

3	<p>c) Ans.</p>	<p>Draw road sign for,</p> <p>i) Load limit ii) Keep left iii) Right hand curve iv) Hospital</p> <p>i) Load Limit: ii) Keep Left</p> <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;">  </div> <div style="text-align: center;">  </div> </div> <p>iii) Right hand Curve iv) Hospital</p> <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;">  </div> <div style="text-align: center;">  </div> </div>	1 mark each	4																
	<p>d) Ans.</p>	<p>State the difference between alignment of hill roads and alignment of plain roads</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 50%; padding: 5px;">Alignment of hill roads</th> <th style="width: 50%; padding: 5px;">Alignment of plain roads</th> </tr> </thead> <tbody> <tr> <td style="padding: 5px;">1. Sharp curves are to be provided</td> <td style="padding: 5px;">1. Sharp curves are not to be provided</td> </tr> <tr> <td style="padding: 5px;">2. Cost of construction is more</td> <td style="padding: 5px;">2. Cost of construction is comparatively less</td> </tr> <tr> <td style="padding: 5px;">3. Proper care has to be taken for drainage</td> <td style="padding: 5px;">3. Drainage does not cause that much problem as compared to hill roads</td> </tr> <tr> <td style="padding: 5px;">4. Stability is more important due to problem of landslides</td> <td style="padding: 5px;">4. There is not much problem of landslides.</td> </tr> <tr> <td style="padding: 5px;">5. Here, more cutting and filling takes place</td> <td style="padding: 5px;">5. Comparatively, less cutting and filling takes place</td> </tr> <tr> <td style="padding: 5px;">6. Slope/ gradient is more</td> <td style="padding: 5px;">6. Slope/Gradient is less</td> </tr> <tr> <td style="padding: 5px;">7. Alignment is difficult</td> <td style="padding: 5px;">7. Alignment is easy</td> </tr> </tbody> </table>	Alignment of hill roads	Alignment of plain roads	1. Sharp curves are to be provided	1. Sharp curves are not to be provided	2. Cost of construction is more	2. Cost of construction is comparatively less	3. Proper care has to be taken for drainage	3. Drainage does not cause that much problem as compared to hill roads	4. Stability is more important due to problem of landslides	4. There is not much problem of landslides.	5. Here, more cutting and filling takes place	5. Comparatively, less cutting and filling takes place	6. Slope/ gradient is more	6. Slope/Gradient is less	7. Alignment is difficult	7. Alignment is easy	1 mark each (Any four)	4
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4	Solve any THREE		12		
a) Ans.	<p>State any four preventive measures of landslides in hilly roads</p> <ol style="list-style-type: none"> By providing proper and effective drainage system to intercept and divert seeping water By constructing buttress at toe and providing retaining structures By providing slopes and their treatment to minimize the erosion By providing soil stabilization By reducing the angle of slopes By stone pitching. By providing nets. Chemical treatment. Growth of vegetation on the slopes. 	1 mark each (Any four)	4		
b) Ans.	<p>Draw labeled sketches of side drains along hill roads.</p>  <p>Stone Pitching Angle Drain Saucer Drain Kerb & Channel Drain 0.60 Road Surface 15cm Dry Stone Pitching</p>	3 marks each and 1 mark for labelling	4		
c) Ans.	<p>State any four causes of failure of rigid pavement</p> <ol style="list-style-type: none"> Defective drainage system may lead to failures in rigid pavements such as mud pumping Use of nondurable materials which start deteriorating during weathering cycles. Improper alignment of dowel bars may lead to stress concentration and cracking near the joints. Defects in construction method and quality control during construction. Increase in the magnitude of wheel loads and the number of load repetitions, exceeding the design values. Structural inadequacy of the pavement structure Inadequate compaction of embankment or subgrade or settlement of embankment foundation itself, which could result in settlement of the supporting layers of the rigid pavement 	1 mark each (Any four)	4		
d) Ans.	<p>Prepare a chart showing schedule of maintenance operation from October to March for bituminous road.</p> <table border="1" data-bbox="235 1596 1291 1890"> <tr> <td data-bbox="235 1596 576 1890">October to December:</td> <td data-bbox="576 1596 1291 1890"> <ol style="list-style-type: none"> Repairing of patch works Renewal of coats Repairing of damages caused by rains Repairing of scours in culverts and cleaning of silts if any Attending road signs, kilometer stones, boards etc. </td> </tr> </table>	October to December:	<ol style="list-style-type: none"> Repairing of patch works Renewal of coats Repairing of damages caused by rains Repairing of scours in culverts and cleaning of silts if any Attending road signs, kilometer stones, boards etc. 	2	4
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		January to March	i) Repairing of patchwork ii) Repairing and inspection of gang huts iii) Renewal and improvement works	2		
4	e)	Justify the remedial measures for the following defects in earthen road:			1 mark each (Any two)	4
	Ans.	i) Formation of dust during dry weather: The dust nuisance may be remedied by the following methods: Frequent sprinkling of water Treatment with calcium chloride Use of other dust palliatives Use of other material like tar, oil etc... ii) Growth of vegetation inside drains and their silting up: The growth of vegetation inside drains should be regularly cleaned either manually or by using machines in order to increase the capacity of the flowing water in the drain. Silting up of weeds, plants, bushes etc. causes obstruction in the flow of water.				
5		Solve any TWO:				12
	a)	Enlist three types of curves provided on hill roads. Draw neat sketch of them			1	6
	Ans.	The three types of curves in hill roads are- a) Hair –Pin Curves b) Salient Curves c) Re-entrant				
					5 (4 marks for sketch one mark for labelling)	
		(Note: All the above three diagrams are to be drawn)				



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	<p>b)</p> <p>Ans.</p>	<p>Calculate the design speed of a vehicle on a horizontal curve having radius of 100m. with permissible super elevation of 7%. Consider co efficient of friction 0.8.</p> <p>Super elevation = $7\% = \frac{7}{100} = 0.07$.</p> <p>R = 100 m.</p> <p>f = 0.8.</p> $e + f = \frac{V^2}{127 R}$ $0.07 + 0.18 = \frac{V^2}{127 \times 100}$ $V^2 = (0.07 + 0.18) \times (127 \times 100)$ $= (0.25) \times (12700)$ $= 3175$ $V = \sqrt{3175} = 56.34 \text{ km/hr.}$	<p>1</p> <p>1</p> <p>2</p> <p>2</p>	
<p>5</p>	<p>c)</p> <p>Ans.</p>	<p>State the requirement of good quality material which plays the major role in highway construction</p> <p>The materials which plays major role in highway construction are:</p> <ol style="list-style-type: none"> Soil Bitumen Cement Stone Concrete Sand <p>Requirements:</p> <p>a) Soil:</p> <ol style="list-style-type: none"> It should be clean and coarse. It should be free from any organic or vegetable matter; It should be chemically inert. It should not contain salts which attract moisture from the atmosphere. It should be well graded, i.e., it should contain particles of various sizes in suitable proportions. It should be strong and durable. It should be clean and free from coatings of clay and silt. <p>b) Bitumen:</p> <ol style="list-style-type: none"> The bitumen should not be highly temperature susceptible During the hottest weather the mix should not become too soft or unstable During cold weather the mix should not become too brittle causing cracks. The viscosity of the bitumen at the time of mixing and compaction should be adequate. This can be achieved by use of cutbacks or emulsions of suitable grades or by heating the bitumen and aggregates prior to mixing. 	<p>3 marks each (for any three type of materials)</p>	<p>6</p>



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v) There should be adequate affinity and adhesion between the bitumen and aggregates used in the mix.

c) Cement:

- i) The color of the cement should be greenish grey.
- ii) Cement should give a cool feeling when hand is thrust into the cement bag
- iii) Cement should give smooth feeling when rubbed between two fingers
- iv) When cement is thrown into a bucket of water it should float for some time and then sink
- v) There should not be presence of lumps

d) Stone:

- i) It should be descent in appearance and have uniform colour.
- ii) It should be durable i.e. it should resist atmospheric action and should be long lasting
- iii) For a good stone, the crushing strength should be more than 100 N/mm²
- iv) Stones should be such that they can be dressed easily and economically.
- v) For a good building stone, the specific gravity should be more than 2.7
- vi) The percentage of water absorption of water by weight after 24 hours should not exceed 60%.
- vii) Minerals in stones should be such that it should catch fire easily.
- viii) Stones should be well seasoned before use.

e) Concrete:

- i) It should have good workability so that it can be easily handled and placed in position.
- ii) It should be dense and compact.
- iii) It should have enough compressive strength.
- iv) It should be durable.
- v) It should be resistant to fire.
- vi) It should be impermeable.
- vii) It should form hard surface capable of resisting abrasion.
- viii) It should have minimum shrinkage.
- ix) It should be economical.

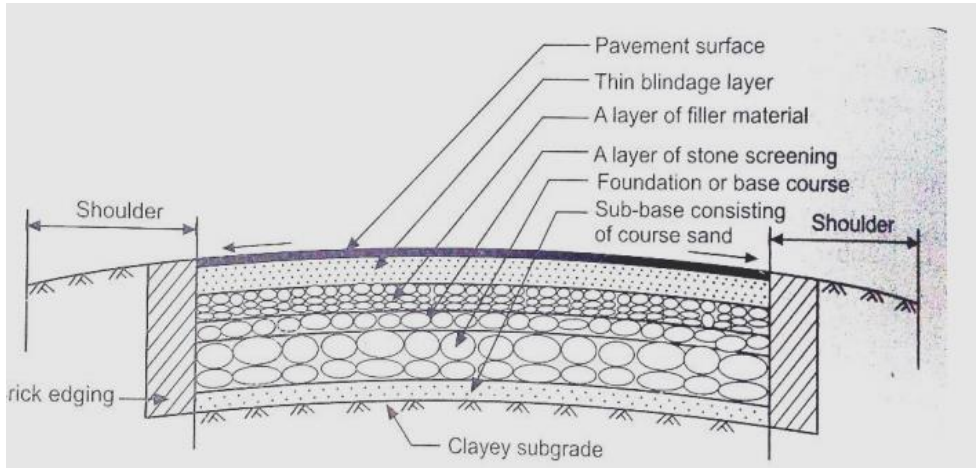
f) Sand:

- i) It should be clean and coarse.
- ii) It should be free from any organic or vegetable matter;
- iii) It should be chemically inert.
- iv) It should contain sharp, angular, coarse and durable grains.
- v) It should not contain salts which attract moisture from the atmosphere.
- vi) It should be well graded, i.e., it should contain particles of various sizes in suitable proportions.
- vii) It should be strong and durable. It should be clean and free from coatings of clay and silt.

5



6	Solve any TWO		12
a)	Write the procedure of construction of WBM road with neat sketch showing various components		
Ans.	Construction Procedure: a) Preparation of Foundation: The foundation for receiving the layer of WBM may be either the sub-grade or sub-base or base course. The depressions and pot holes on the existing road surface are filled up and the corrugations are removed by scarifying and reshaping the surface to the required grade and reshaping camber as necessary. b) Spreading of coarse aggregate: The coarse aggregate is spread uniformly on the prepared base. The WBM course is normally constructed to compacted thickness of 7.5cm. c) Rolling: After spreading the coarse aggregates properly, compaction is done by a three wheeled power roller of capacity 6 to 10 tonnes or alternatively by an equivalent vibratory roller; the weight of the roller depends on the type of coarse aggregates. The rolling is done until adequate compaction is achieved. d) Application of Screenings: After the coarse aggregates are rolled adequately, the dry screenings are applied gradually over the surface to fill the interstices (Voids) in three or more applications. Dry rolling is continued as the screenings are being spread and brooming is carried out. e) Sprinkling and Grouting: After the application of screenings, the surface is sprinkled with water, swept and rolled. Wet screenings are swept into the voids using hand brooms. Additional screenings are applied and rolled till the coarse aggregates are well bonded and firmly set. f) Application of binding materials: After the application of screening and rolling, binding material is applied at a uniform and slow rate at two or more successive thin layers. After each application of binding material, the surface is copiously sprinkled with water and wet slurry swept with brooms to fill the voids. This is followed by rolling with a 6 to 10 tonnes roller and water is applied to the wheels to wash down the binding material that sticks to the roller. When crushable type screenings like moorum or gravel are used, there is no need to apply binding materials, except in the surface course. g) Setting and Drying: After final compaction, the WBM course is allowed to set over night. On the next day, the hungry spots are located and are filled with screenings and binding material, lightly sprinkled with water and rolled. No traffic is allowed till WBM layer sets and dries out.	4	6



OR



2

b)
Ans.

Explain the Divisional Island with neat sketch

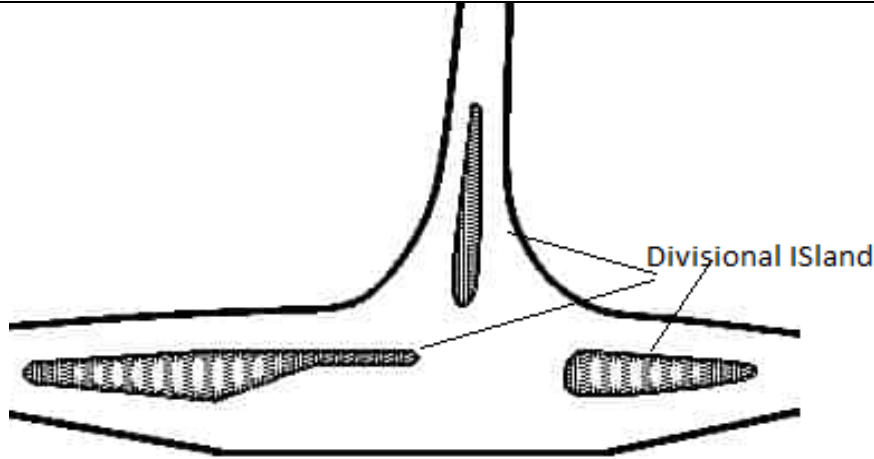
These types of Island are constructed to separate the traffic from opposite directions in a highway having four or more lanes. Thus, by providing such type of island the highway is divided into two one way roadways, eliminating head on collision and other accidents.

The width of such islands is more to avoid headlight glare during night driving.

The kerb should be high enough to prevent vehicles from entering into the islands

4

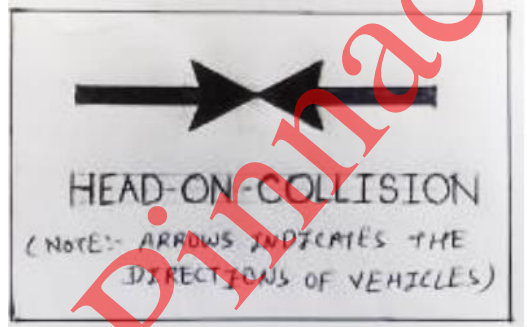
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c) Draw the Collision Diagram for,
i) Head on collision
ii) Rear end collision
iii) Side Sweep

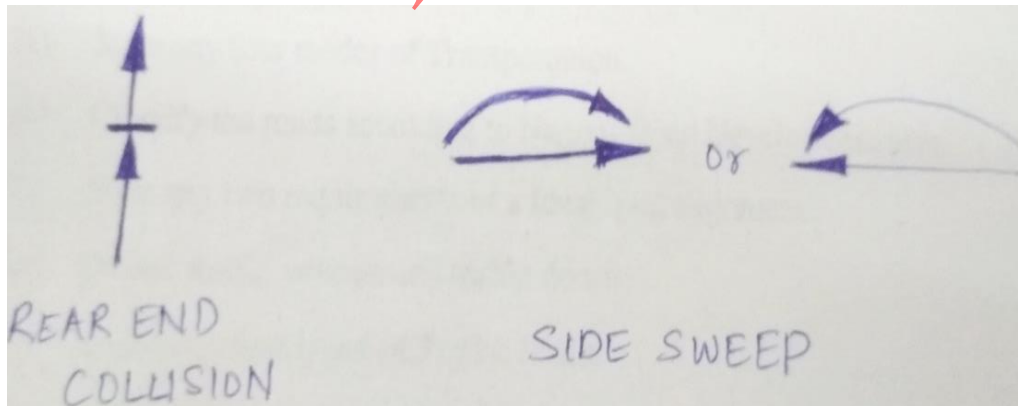
Ans.

i) Head on Collision:



ii) Rear end

iii) Side sweep



2 mark each

6