Transportation Depth Topics

School of PE

Workshop Problems

Code: CITEP-D **Spring 2015**

PROBLEM 1

A local survey crew measures a distance of 2,500 ft for a new road construction. The beginning point for the road is located at station 5+00. What is the station of the end point of the road?

A) 30.00 Sta B) Sta 3+00 C) 3.00 Sta D) Sta 30+00

SOLUTION 1

PROBLEM 2

A vehicle is traveling at 60 mph on a level roadway when the driver notices traffic stopped in its path. If the driver's perception reaction time is 2.5 seconds, approximately how much distance does the driver take to perceive, decide, react, and stop the vehicle at a deceleration rate of 11.2 ft/sec^2 after noticing the stopped traffic?

A) 220 ft B) 345 ft C) 570 ft D) 645 ft

SOLUTION 2

PROBLEM 3

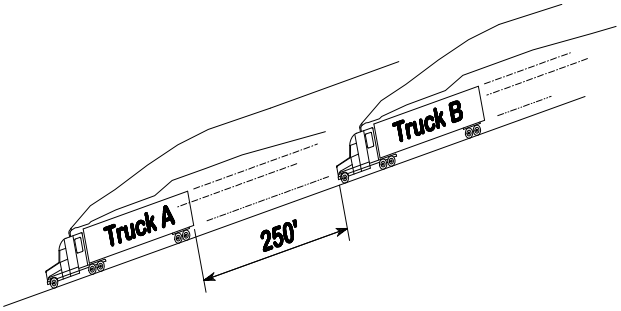
Two vehicles are traveling in the same direction at different speeds on a two-lane rural highway. The lead vehicle is traveling at 40 mph speed. The following is traveling at 50 mph and intends to overtake and pass the lead vehicle. What is the approximate passing sight distance required in this situation.

A) 600 ft B) 700 ft C) 800 ft D) 900 ft

SOLUTION 3

PROBLEM 4

Two semitrailers are traveling down a 5.5% grade at 40 mph on a two lane highway in the same lane. Truck A has new tires. Truck B has worn tires. The roadway is paved with Portland cement concrete.



Driver A suddenly slams on the brakes to make a panic stop. Assume it takes Driver B 1.5 seconds to react to Driver A.

Friction factors for New Tires = 0.76; Friction factors for Worn Tires = 0.33

(a) What is the new distance between Trucks A & B?
(b) Repeat the problem assuming Truck A has worn tires and Truck B has new tires.
(c) Repeat the original problem assuming the trucks are going up the 5.5% grade, Truck B following Truck A.
(d) Repeat case (b) with both trucks heading up the 5.5% grade.

SOLUTION 4

Case	Truck A	Truck B	New Distance
(a)	$s_{bA} = 1.47t_p V_{mph} + \frac{V_{mph}^2}{30(f+G)} \Rightarrow$ *CERM eqn.*79.43(*b*) $s_{bA} = 1.47 \times 0 \times 40 + \frac{40^2}{30(0.76-0.055)} = 75.65'$ $s_{bA} \sim 76'$	$s_{bB} = 1.47t_p V_{mph} + \frac{V_{mph}^2}{30(f+G)}$; $s_{bB} = 1.47 \times 1.50 \times 40 + \frac{40^2}{30(0.33-0.055)}$ $s_{bB} = 88.2' + 193.94' = 282.14' \sim 283'$	76'+250'-283'=43'
(b)			
(c)			
(d)			

PROBLEM 5

For a circular curve, what is its degree of curve for the following:

i) A Roadway curve with 800 feet radius

A) $7^0 9'43"$ B) $8^0 51'18"$ C) $8^0 55'55"$ D) $7^0 51'18"$

ii) A Railroad curve with 800 feet radius

A) $6^0 50'55"$ B) $7^0 10'00"$ C) $8^0 55'55"$ D) $7^0 51'18"$

SOLUTION 5

PROBLEM 6

A running race track consists of two semicircles and two tangents, and is exactly five miles long as measured along its centerline of the perimeter. The two semicircular curves constitute exactly one-half its totally length.

i) What is the length of each curve?

A) 26,400 ft B) 13,200 ft C) 6,600 ft D) 3,300 ft

ii) What is the radius of each curve?

A) 4,000 ft B) 3,204 ft C) 1,208 ft D) 2,101 ft

iii) What is the degree of curvature of each curve?

A) $2^0 43'37"$ B) $2^0 20'27"$ C) $3^0 43'42"$ D) $3^0 20'27"$

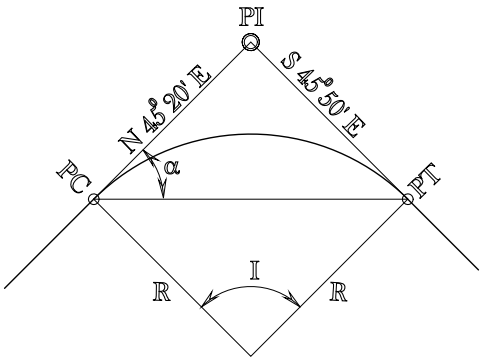
SOLUTION 6

PROBLEM 7

Determine angle 'α' for the following circular curve:

A) $44^0 40'$ B) $44'25''$ C) $88^0 50'$ D) $44^0 25'$

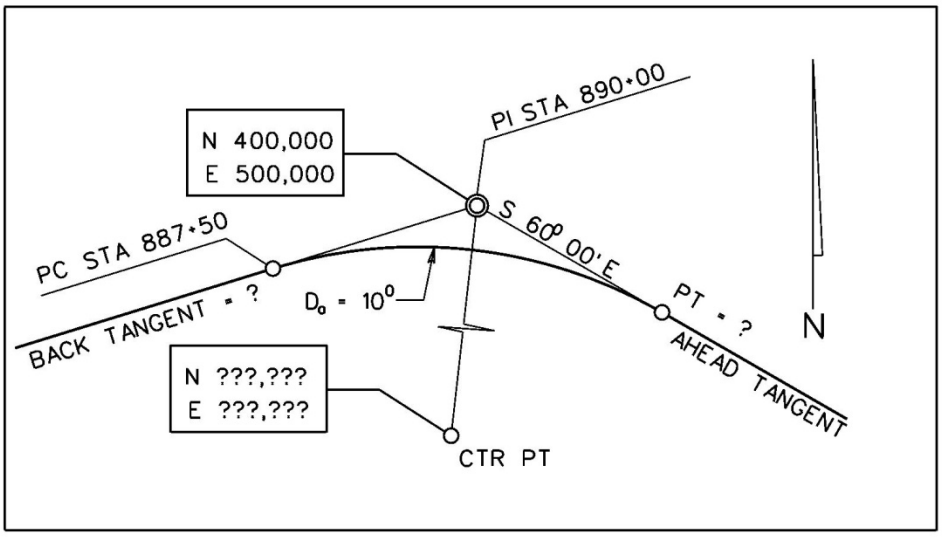
SOLUTION 7



PROBLEM 8

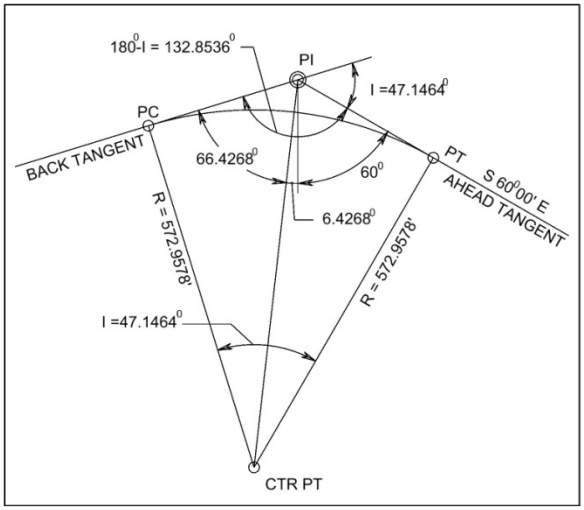
A horizontal curve is shown in the figure below. Using the information provided, determine the following:

i) the back tangent bearing
ii) the PT Station
iii) PT Coordinate
iv) the coordinates of the Center Point.



SOLUTION 8

Basic Approach –



- Draw a rough sketch of the curve, paying careful attention to the Ahead Tangent Bearing. It should resemble CERM Figure 79.1
- Use CERM Equation 79.1 to solve for R.
- Find the tangent length, T.
- Use CERM Equation 79.4 to solve for I.
- Use CERM Equation 79.3 to solve for L.
- Determine the bearing of the back tangent
- Determine the PT Station
- Use the above values and trigonometry to find the coordinates of the PT, Center Point.
- Use CERM Equation 79.5 to solve for E.
- Check the Center Point coordinates using trigonometry and working from the PI.

$R = 5729.578 / D_a$	=	$5729.578 / 10^0$	= 572.9578 ft.
T = PI Sta. – PC Sta.	=	89000.00 – 88750.00	= 250.00 ft.
$I = 2 \tan^{-1}(T/R)$	=	$2 \tan^{-1}(250.00/572.9578)$	= 47.1464^0
$L = 2\pi RI/360^0$	=	$2\pi 572.9578(47.1464^0)/360^0$	= 471.464 ft

PROBLEM 9

A four-lane undivided highway has a design speed of 40 mph. The lanes are 12 ft wide. The centerline Degree of Curvature, D is 10^{o} 45' Determine the required clearance (or in other words HSO) from the center of the curve's inside lane (or in other words center line of the lane with the shortest radius) based on Stopping Sight Distance criteria.

A) 22.41 ft B) 21.67 ft C) 305 ft D) 533 ft

SOLUTION 9

PROBLEM 10

You are travelling on a two-lane highway in eastbound direction that curves to the right. The following curve data describes the centerline: $D_a = 9^o30'$; PI Sta. 16+00. The lanes are 12-feet wide and a continuous hedge of 8-foot high trees is located along the right side of the highway in your travel direction, exactly 29.32 ft from the highway centerline. Based on this data, what should be the maximum safe design speed of this highway?

SOLUTION 10

PROBLEM 11

A rural highway curve has a radius of 150 m (500 ft.) and a superelevation of six percent. If the posted speed limit is 55 mph, what is the MOST appropriate advisory speed for this curve?

A) 50 mph B) 45 mph C) 40 mph D) 35 mph

SOLUTION 11

PROBLEM 12

A two lane highway curves to the right. The lanes are each 12-ft wide. The following information is provided:

Design Speed	55 mph
Normal cross slope	2.0%
Superelevation	6.2%
PC Station	Sta. 657+50.00
PT Station	Sta. 668+90.00
Superelevation runoff rate	1:213

The superelevation is to be developed by rotating the pavement about the roadway centerline and using the 2/3 and 1/3 rule. Use the above information to determine:

i) Superelevation runoff

A) 76 ft B) 158 ft C) 67 ft D) 327 ft

ii) Tangent runout

A) 51 ft B) 237 ft C) 67 ft D) 327 ft

iii) The station where normal crown ends (approaching the curve)

A) Sta 655+92 B) Sta 655+94 C) Sta 657+50 D) Sta 668+90

iv) The station where superelevation runoff begins (approaching the curve)

A) Sta 655+92 B) Sta 656+45 C) Sta 657+50 D) Sta 668+90

v) The station where full superelevation ends (leaving the curve)
A) Sta 668+90 B) Sta 670+48 C) Sta 668+37 D) Sta 657+50

vi) The station where superelevation runoff ends (leaving the curve)
A) Sta 668+90 B) Sta 669+95 C) Sta 668+11 D) Sta 657+50

SOLUTION 12

PROBLEM 13

A new rural highway is to be designed with a design speed of 70 mph and a max rate of superelevation, e_{max} = 0.08 ft/ft. The highway will have a curve of degree of curvature 3^0. A design criterion requires that this curve be spiraled.

i) What is the length of spiral curve given the rate of increase of lateral acceleration is 2 ft/sec^3?

A) 1910 ft B) 5729 ft C) 179 ft D) 283 ft

ii) What is the rate of change in degree of curvature (in degrees per station) along the spiral?

A) 3^0 B) 2.87^0 C) 1.50^0 D) 1.06^0

SOLUTION 13

PROBLEM 14

The horizontal alignment of an interchange exit ramp consists of a series of three consecutive and progressively sharper circular curves that form a single compound circular curve. Proceeding in the direction of traffic, if the first curve has degree of curvature, $D_a = 2^0$, what is the minimum radius of the third curve?

A) 2865 ft B) 1432 ft C) 716 ft D) 358 ft

SOLUTION 14

PROBLEM 15

A +5.00 % grade intersects a -2.75% grade at Sta. 21+75, and elevation 1682.20 ft. A 400-ft vertical curve connects the two grades. Determine:

i) the turning point station

A) Sta 19+75 B) Sta 21+75 C) Sta 22+33 D) Sta 23+75

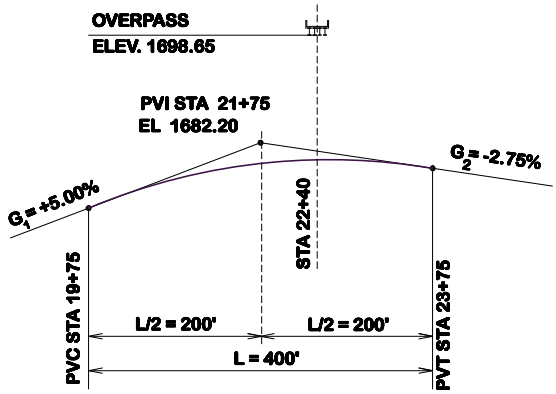
ii) the turning point elevation

A) 1698.65 ft B) 1678.65 ft C) 1682.20 ft D) 1700.00 ft

iii) clearance available at the overpass point above the vertical curve (Overpass is located at Sta 22+40 with bottom of beam elevation 1698.65 ft)

A) 1698.65 ft B) 1678.65 ft C) 20.00 ft D) 26.45 ft

SOLUTION 15

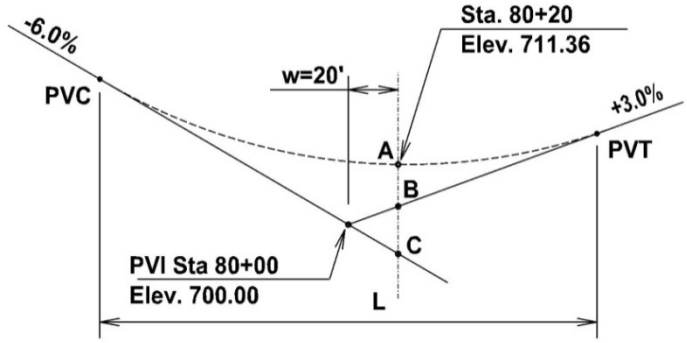


PROBLEM 16

A -6.0% grade intersects a +3.0% grade at PVI Sta. 80+00 and Elev. 700.00. The vertical curve connecting the grades passes through a fixed point located at Sta. 80+20, and elevation 711.36. What is the length of the vertical curve?

A) 698 ft B) 711 ft C) 1035 ft D) 1200 ft

SOLUTION 16



PROBLEM 17

A -6.0% grade intersects a +3.0% grade at PVI Sta. 80+00 and Elev. 700.00. The vertical curve connecting the grades passes through a turning point at elevation 711.36. What is the length of the vertical curve?

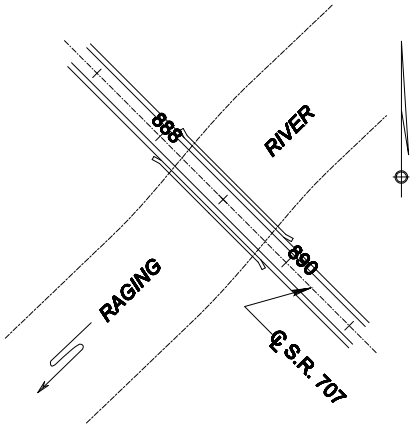
A) 700 ft B) 1136 ft C) 1200 ft D) None of the above

SOLUTION 17

PROBLEM 18

State Route (S.R.) 707 crosses the Raging River in a narrow mountain valley. After a heavy storm the river overtops the bridge and crests at elevation 560.00. Given the vertical alignment data, determine:

S.R. 707 Vertical Alignment	
PVI Station	889+50
PVI Elev	545.00
L =	500 ft
G_1 =	-4.0%
G_2 =	+3.0%



i) How deep the water is at Station 890+50 at the roadway centerline?

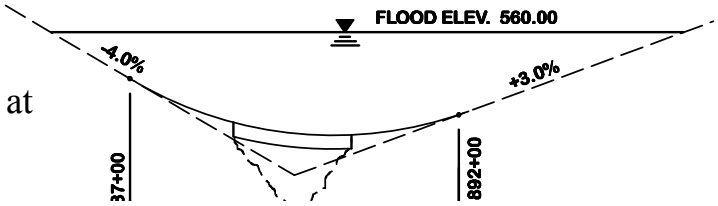
A) 10.42 ft B) 15.00 ft C) 0 ft D) 10.71 ft

ii) How deep is the water at the low point in the profile?

A) 10.42 ft B) 15.00 ft C) 0 ft D) 10.71 ft

SOLUTION 18

i) First, find the elevation on the vertical curve at Sta. 890+50.



ii) First, find the elevation on the vertical curve at the lowest point on the curve.

PROBLEM 19

An unlighted roadway is on a vertical curve with the following parameters: $G_1 = -4.5\%$, $G_2 = +2.0\%$, L = 600 ft. Based on AASHTO criteria, determine:

i) the actual head light sight distance (HLSD) of the curve

A) 413 ft B) 851 ft C) 0 ft D) 500 ft

ii) the maximum design speed (based on HLSD)

A) 40 mph B) 45 mph C) 55 mph D) 60 mph

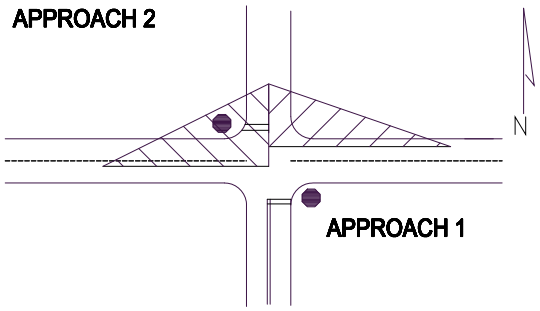
SOLUTION 19

i)

ii)

PROBLEM 20

You are the city engineer and recently you have been asked to evaluate the stop sign controlled intersection described in the figure below. In this intersection the major road is a two-lane east-west highway with a speed limit of 55 mph. The minor road is a two-lane north-south highway with a speed limit of 35 mph. Compute the following items for approach 1 with 4% uphill for single unit truck design vehicle. You may assume a lane width on the minor road as 11 feet and a lane width on the major road as 12 feet.



i) Determine the maximum length of the "a_1" leg of the intersection sight triangle for a RIGHT turn at Approach 1.

ii) Determine the lengths of the "b" leg of the intersection sight triangle for a RIGHT turn at Approach 1.

iii) Determine the maximum lengths of the "a_2" leg of the intersection sight triangle for a LEFT turn at Approach 1.

A) 36 ft B) 76 ft C) 687 ft D) 606 ft

iv) Determine the lengths of the "b" leg of the intersection sight triangle for a LEFT turn at Approach 1.

A) 768 ft B) 868 ft C) 832 ft D) 606 ft

SOLUTION 20

Reference: AASHTO Green Book pages 9-28 to 9-41

A right turn is expressed by Case B2 per AASHTO for i) and ii)

i) a_1 = 18 ft which is the max per page 9-36 + ½ LW = 18 + 6 = 24 ft

ii) b = ISD = 1.47 V_{major} t_g = 1.47 x 55 (8.5+0.1x4) = 719.6 ft

NOTE: For t_g value, see Table 9-6 in AASHTO Green Book

PROBLEM 21

A new interchange will be located on a north-south highway with a design speed of 70 mph. The northbound exit will have a -2.0% grade and an exit curve with a design speed of 40 mph. Ramp is a taper type.

i) What is the minimum deceleration length, L, on the northbound exit ramp?
A) 490 ft B) 440 ft C) 550 ft D) 340 ft

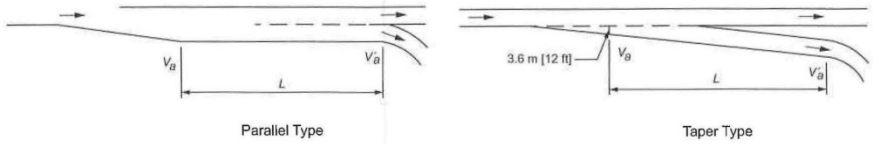
ii) What is the average running speed, V'_a, on the northbound exit ramp exit curve?
A) 30 mph B) 40 mph C) 38 mph D) 36 mph

SOLUTION 21

Referring to the table below,

U.S. Customary										
Deceleration Length, L (ft) for Design Speed of Exit Curve V' (mph)										
Highway Design Speed, V (mph)	Speed Reached, V_a (mph)	Stop Condition	15	20	25	30	35	40	45	50
		For Average Running Speed on Exit Curve, V'_a (mph)								
		0	14	18	22	26	30	36	40	44
30	28	235	200	170	140	—	—	—	—	—
35	32	280	250	210	185	150	—	—	—	—
40	36	320	295	265	235	185	155	—	—	—
45	40	385	350	325	295	250	220	—	—	—
50	44	435	405	385	355	315	285	225	175	—
55	48	480	455	440	410	380	350	285	235	—
60	52	530	500	480	460	430	405	350	300	240
65	55	570	540	520	500	470	440	390	340	280
70	58	615	590	570	550	520	490	440	390	340
75	61	660	635	620	600	575	535	490	440	390

V = design speed of highway (mph)
V_a = average running speed on highway (mph)
V' = design speed of exit curve (mph)
V'_a = average running speed on exit curve (mph)



Parallel Type Taper Type

AASHTO Green Book Table 10-5. Minimum Deceleration Lengths for Exit Terminals with Flat Grades of Two Percent or Less.

PROBLEM 22

A traffic study of an urban freeway corridor identified the locations with the highest incidence of crashes. The corridor includes three freeway segments and three interchanges. Using the crash data and traffic volumes tabulated below,

a. Rank the interchanges by number of crashes per year per million vehicles for each interchange from highest to lowest.
b. Rank the highway segments by number of crashes per year per million vehicle miles.

Inchg Exit	ADT	Crashes per yr
48	28500	73
55	11250	49
58	23150	68

Highway Segment	ADT	Crashes per yr	Segment Length
48 to 55	68000	890	7.18
55 to 58	72000	490	3.12
58 to 61	63000	478	2.96

SOLUTION 22

a. Interchanges Ranking

b. Highway segments. Use 10^6 instead of 10^8 because the ranking is per million vehicle miles, not 100 million.

PROBLEM 23

On a four lane undivided highway in north-south direction, right most lane in the northbound direction needs some repairs for one mile long. The 85th percentile speed on this highway is 45 MPH. All lanes are 12 feet wide and the shoulders are 6 feet wide. What is the most appropriate merge taper length to place cones for this work zone inside the northbound right most lane?

A) 203 ft B) 270 ft C) 405 ft D) 540 ft

SOLUTION 23

PROBLEM 24

Shoulder work needs to be completed on an urban two-lane low speed highway. The 85th percentile speed is 25 MPH and the offset required is 12 ft. How far in advance of the shoulder work area should the very first sign be placed that drivers will see notifying them of the road work?

A) 125 ft B) 200 ft C) 242 ft D) 42 ft

SOLUTION 24

PROBLEM 25

Shoulder work needs to be completed on a freeway. The 85th percentile speed is 65 MPH and the offset required is 18 ft. How far in advance of the first cone should a driver see the first "Right Side Shoulder Closed" sign?

A) 1000 ft B) 1500 ft C) 1890 ft D) 2890 ft

SOLUTION 25

Workshop Problems

PROBLEM 1

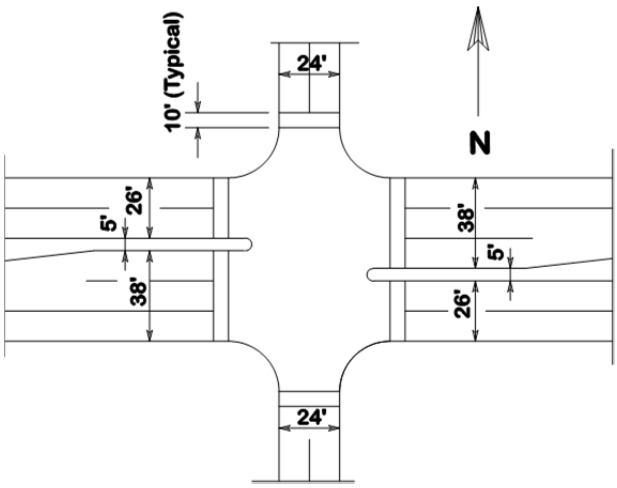
A 5-mi undivided 4-lane highway is located on level terrain. A 6,200-ft. segment with 2.5 percent grade also is included in the study. Determine the peak hour LOS for the upgrade portion of the highway given the following:

- 46.0 mi/h field-measured FFS; 11-ft lane width
- 1,900 veh/h peak-hour-volume in one direction
- 13 percent trucks and buses; 2 percent RVs
- 0.90 PHF; and commuter traffic

SOLUTION 1

PROBLEM 2

The signalized intersection shown in the figure is located in a suburban area near a retirement home with pedestrian volumes of 10 ped/cycle. Determine the minimum green time for North-South pedestrian intervals.



SOLUTION 2

PROBLEM 3

A signalize four-leg intersection has the adjusted flow rates and total delays by approach indicated below. Based on this data and the HCM LOS criteria for signalized intersections provided below, determine the:

(a) LOS of each approach.
(b) Average control delay of the intersection.
(c) LOS of the intersection.

Approach	EB	WB	NB	SB
Adjusted flow rate, (vph)	491	672	825	858
Avg. Control Delay by approach (sec/veh)	16.2	23.6	58	32.0

SOLUTION 3

a)

b)

c)

PROBLEM 4

The traffic volumes for a two phase signal at the intersection of First Street and Main Street are summarized below:

Street	Flow Rate	Max Saturation Flow
First St.	890 vph	2400 vph
Main St.	750 vph	1800 vph

- lost time/ phase: 4 sec;
- desired intersection volume to capacity ratio = 0.90

What Cycle length should be used?

SOLUTION 4

PROBLEM 5

A two-phase signal has flow ratios on the major roadway as 0.46 and the minor roadway as 0.29, and the assumed lost time of 4.0 sec/phase. Estimate the minimum cycle length.

SOLUTION 5

PROBLEM 6

A 20 ft wide sidewalk along a highway is bordered by curb with trees on one side and fence on the other side. The peak 15-min pedestrian flow rate is 1,600. What is the LOS during the peak 15 min on the average with no other obstructions on the side walk?

SOLUTION 6

1. **Sign Mounting Height 1.** The minimum mounting height (ft) to the bottom of a sign above sidewalk is most nearly
   (A) 5
   (B) 6
   (C) 7
   (D) 8

Solution:
See Section 2A.18, *Mounting Height*. The minimum height measured vertically from the bottom of the sign to the sidewalk, of signs installed above sidewalks shall be **7 feet.**

The correct answer is C

2. **Sign Mounting Height 2.** The minimum vertical clearance (ft) to the bottom of an overhead sign above pavement and shoulder is most nearly
   (A) 16.0
   (B) 17.0
   (C) 18.5
   (D) 18.0

Solution:
See Section 2A.18, *Mounting Height*. Paragraph 14, "Overhead signs shall provide a vertical clearance of not less than **17 feet** to the sign, light fixture, or sign bridge over the entire width of the pavement and shoulders except where the structure on which the overhead signs are to be mounted or other structures along the roadway near the sign structure have a lesser vertical clearance."

The correct answer is B.

3. **Chevron Alignment Signs.** You are designing a rural highway with a design speed of 50 mph, but a sharp curve with a maximum design speed of 45 mph requires horizontal alignment warning signs. In addition to an advisory speed plaque, you place chevron alignment (W1-8) signs along the outside of the curve. What is the appropriate spacing (ft) of the chevron alignment signs?
   (A) 80
   (B) 120
   (C) 160
   (D) 200

Solution:
For the situation described above see Section 2C.09 Chevron Alignment Sign (W1-8). According to Table 2C-6, Typical Spacing of Chevron Alignment Signs on Horizontal Curves, the required sign spacing is **120 feet**

The correct answer is B.

4. **Exit Sign.** I-65 is an urban freeway. You are designing an exit sign to be located between the main roadway and the ramp just beyond where the ramp branches from the freeway. The sign shall carry the word "Exit", the exit number, and an appropriately upward slanting arrow. The Gore exit number is 44B. What is the minimum size (inches) of the sign panel?
   (A) 78 x 60
   (B) 108 x 60
   (C) 138 x 30
   (D) 138 x 30

Solution:
The required sign is described as "Exit Gore (with exit number)," and is designated "E5-1a." It has a 2-digit exit number (with a single letter suffix). According to Table 2E-1, the minimum size is 108 x 60.

The correct speed is B.

5. **Traffic Signal Mounting Height 1.** The maximum height (ft) of the top of the signal housing of a vehicular signal face located over any portion of a highway that can be used by motor vehicles is
   (A) 22.3
   (B) 24.0
   (C) 25.6
   (D) 28.5

Solution:

See Section 4D.15, *Mounting Height of Signal Faces*. The top of the signal housing of a vehicular signal face located over any portion of a highway that can be used by motor vehicles shall not be more than **25.6 feet** above the pavement.

The correct answer is C.

6. **Traffic Signal Mounting Height 2.** The maximum height (ft) of the top of the signal housing of a vehicular signal face located 48.5 feet from the stop bar is most nearly
   (A) 22
   (B) 23
   (C) 24
   (D) 25

Solution:
See Figure 4D-5, *Maximum Mounting Height of Signal Faces Between 40 Feet and 53 Feet from the Stop Line*. The figure indicates the top of the signal housing shall not be more than **24 feet** above the pavement for 48.5 ft from the Stop line.

The correct answer is C.

7. Ped / Bike Trail 1. A city park is proposing a new path for shared use by pedestrians and bicyclists. What is the minimum sign size (inches) of a "Shared-Use Path Restriction" (R9-7)sign?

(A) 9 x 15
(B) 12 x 18
(C) 18 x 12
(D) 18 x 18

Solution:
According to MUTCD Table 9B-1, *Bicycle Facility Sign and Plaque Minimum Sizes*, a "Shared Path Restriction" sign, (R9-7), requires a minimum size of **12 x 18.**

The correct answer is B.

8. Ped / Bike Trail 2. The proposed ped / bike path described above crosses a busy roadway. A post-mounted "No Motor Vehicles" sign is located adjacent to the path immediately beyond the intersection. What is the minimum mounting height (ft) of the bottom of the sign relative to the edge of path?

(A) 4
(B) 6
(C) 7
(D) 8

Solution:
According to Figure 9B-1, *Sign Placement on Shared-Use Paths*, the minimum mounting height (ft) of the bottom of the sign is 4 ft above the edge of path.

The correct answer is A.

9. Speed Limit. A city has decided to conduct a traffic study on one of their busy streets to determine the speed limit. They collected a large sample of data during free-flowing traffic conditions and determined that the 85th percentile speed of the traffic is 46.8 mph. Which of the following posted speed limit signs are most appropriate for these conditions?

A) 40 mph, 45 mph, or 50 mph
B) 40 mph or 45 mph
C) 45 mph or 50 mph
D) 50 mph or 55 mph

Solution:
Posted speed limit should be within 5 mph of the 85th percentile speed of the free-flowing traffic.

Low range is 46.8 – 5 = 41.8 mph (can't be lower than 41.8 mph and therefore, the low speed is 45 mph)

High range is 46.8+5 = 51.8 mph (can't be higher than 51.8 mph and therefore, the high speed is 50 mph)

The correct answer is C

Workshop Problems

1. **Workshop Problem - Guide Sign 1.** You are designing guide signs for a new major interchange of a freeway connecting another freeway. What is the minimum size (inches) of upper-case letters to be used for the names of destinations shown on sign legends?
   (A) 12
   (B) 15
   (C) 16
   (D) 20

Solution:

2. **Workshop Problem - Guide Sign 2.** You are designing new guide signs for Enterprise Avenue, an urban street with a posted speed of 25 mph. What is the minimum size (inches) upper letters to be used for the principal legend.
   (A) 3.0
   (B) 3.5
   (C) 4.0
   (D) 5.0

Solution:

3. **Workshop Problem - Pedestrian Signal Head.** A flashing WALKING PERSON indication symbolizes which of the following?

   (A) A pedestrian facing the signal indication is permitted to start to cross the roadway.
   (B) A pedestrian facing the signal indication shall not start to cross the roadway because the signal is about to change.
   (C) A pedestrian facing the signal indication should yield the right-of-way to vehicles lawfully within the intersection at the time this indication is first shown.
   (D) Nothing. A flashing WALKING PERSON indication has no meaning and shall not be used.

Solution:

4. **Workshop Problem - Lane Reduction 1.** Ridge Road is a three lanes wide (two lanes northbound / one lane southbound) as it heads north from Downtown and up-hill into Valley View Park. The lanes are all 12-feet wide and the 85^{th} percentile speed throughout is 40 mph. A short distance beyond the crest of the hill, the two northbound lanes reduce to one lane. The required length of taper (ft) for the lane reduction is most nearly:
   (A) 240
   (B) 280
   (C) 320
   (D) 480

Solution:

5. Workshop Problem - Lane Reduction 2. A "Lane Ends" (W4-2) warning sign is placed on the side of the northbound lanes a short distance to the south of the Ridge Road lane reduction described above. The required advance placement (ft) for the lane reduction taper is most nearly:

(A) 670
(B) 775
(C) 885
(D) 990

Solution:

14. Workshop Problem - Delineators. A rural interchange contains an entrance ramp with a 14^0 horizontal curve.

Determine the appropriate spacing (ft) of delineators along the curve.

(A) 55
(B) 60
(C) 65
(D) 70

Solution:

15. **Workshop Problem - Railroad Grade Crossing 1.** A two-lane highway with an 85th percentile speed of 60 mph crosses a railroad. How far (ft) in advance of the grade crossing should a Highway-Rail Grade Crossing sign (W10-1) be located?
    (A) 250
    (B) 325
    (C) 400
    (D) 1,100

Solution:

16. **Workshop Problem - New Traffic Control Signal Installation.** The installation of a new traffic control signal at an existing intersection is most likely to cause which of the following traffic conflicts to increase?
    (A) Minor street left-turn and major street right turn
    (B) Through movements in opposing directions
    (C) Through movements in same direction
    (D) Through movements on crossing streets

Solution:

17. **Workshop Problem - Invalid Warrant.** Which of the following is not a valid warrant for installing a traffic control signal?
    (A) Two- hour Vehicular Volume
    (B) Peak Hour
    (C) Crash Experience
    (D) School Crossing

Solution:

1. Which of the following combinations of foreslope (vertical to horizontal) and backslope (vertical to horizontal) is NOT an AASHTO preferred cross-section for channels with abrupt slope changes?

(A) 1:5 and 1:3
(B) 1:5 and 1:5
(C) 1:5 and 1:8
(D) 1:5 and 1:10

SOLUTION

See Figure 3-6, p. 3-9

The 1:5 and 1:3 combination is the only one that does not fall in the "Preferred Channel Cross-Section" of the graph area. Therefore, the correct answer is A.

2. Which of the following is most nearly the AASHTO–suggested shy-line offset to place a barrier from the obstacle, (ft) for 55 mph?

(A) 5
(B) 6
(C) 7
(D) 8

SOLUTION

See reference Table 5-7, p. 5-41. For design speed of 55 mph, shy-line offset is 7 ft. Therefore, the correct answer is C.

3. A two-lane highway has an ADT of 4,900 and a design speed of 50 mph. The AASHTO recommended Runout Length, (L_R), (ft) in this situation to protect an object is most nearly which of the following:

(A) 380
(B) 250
(C) 160
(D) 110

SOLUTION

See reference Table 5-10(b), p. 5-50. For ADT between 1,000 and 5,000 and for 50 mph design speed, Runout Length is 160 ft. Correct answer is C.

4. You have been asked to analyze the roadside safety of a park road with a posted speed limit of 45 mph. You notice several 2-inch diameter trees within the 18-foot clear zone. You know that this species of deciduous tree has an expected mature diameter of 3-inches. Which of the following is the appropriate roadside safety improvement strategy.

(A) Remove the trees from within the clear zone width.
(B) Provide shielding to protect motorists from the trees.
(C) Reduce the speed limit by 20 mph.
(D) Do nothing.

SOLUTION

See *Section 4.9 Trees, page 4-15, second paragraph, first sentence*

"Trees are potential obstructions by virtue of their size and their location in relation to vehicular traffic. Generally, an existing tree with an expected mature size greater than 100 mm [4 in.] at stub height is considered a fixed object."

Therefore the correct answer is D, do nothing.

Workshop Problems

1. **Workshop Problem -** A two-lane rural highway has a design speed of 65 mph and a Design ADT of 8800 vpd. It has 12-foot lanes and 10-foot shoulders, and is located in a rock cut with backslopes of 1V:6H. A utility company plans to install poles along the right side of the highway for a new electric transmission line in an area where the roadway curves to left on a 1640 foot radius curve. The utility should place the poles beyond what range of required clear-zone distance (ft) to avoid the need to protect them?

   (A) 14 to 16
   (B) 20.7 to 22.8
   (C) 28 to 30
   (D) 36.4 to 39

   SOLUTION

2. **Workshop Problem -** Which of the following combinations of foreslope (vertical to horizontal) and backslope (vertical to horizontal) is NOT an AASHTO preferred cross-section for channels with gradual slope changes?

   (A) 1:4 and 1:3
   (B) 1:4 and 1:5
   (C) 1:4 and 1:6
   (D) 1:4 and 1:10

   SOLUTION

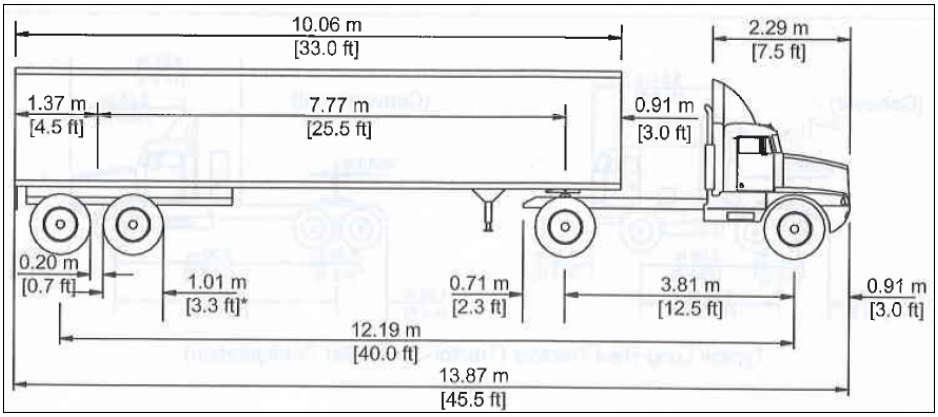
1. What is the overall height, (ft), of an Articulated Bus (A-BUS)?

(A) 9.5
(B) 10.0
(C) 11.0
(D) 12.0

SOLUTION:
Reference Table 2-1b, p. 2-4
Answer C

2. What design vehicle type symbol the following vehicle falls under?

(A) WB-40
(B) WB-45.5
(C) WB-67
(D) WB-90



SOLUTION:
Reference Figure 2-13, p. 2-22

Answer A

Clue: Vehicle Design number is typically close to the distance between the front and rear axles of the vehicle. In the above figure, it is 40 ft and therefore, it is WB-40.

3. On rural highways with average fluctuation in traffic flow, the 30 HV is typically about ___ percent of the ADT?

(A) 10
(B) 11
(C) 15
(D) 17

SOLUTION:
Reference p. 2-47, paragraph 5
Answer C

4. The estimated crash rate per Million Vehicle-Miles of Travel on suburban roadways with a total of 30 Driveways per mile and Two-Way Left-Turn (TWLT) Lanes is most nearly:
(A) 5
(B) 6
(C) 8
(D) 10

SOLUTION:
Reference Figure 2-32, p 2-75
Answer B

5. The speed (fps) at which the average pedestrian walks is most nearly:
(A) 2.5 to 6.0
(B) 5.5 to 9.0
(C) 8.5 to 12.0
(D) 11.5 to 15.0

SOLUTION:
Reference Section 2.6.3, p 2-79
Answer A

6. The average running speed (mph) on a roadway designed for 70 mph is most nearly:
(A) 58
(B) 60
(C) 62
(D) 64

SOLUTION:
Reference Table 3-6, p 3-29
Answer A

7. What is the maximum grade on a rural collector road with a design speed of 45 mph in mountainous terrain?

(A) 9%
(B) 10%
(C) 11%
(D) 12%

SOLUTION:
Reference Table 6-2, p 6-3
Answer B

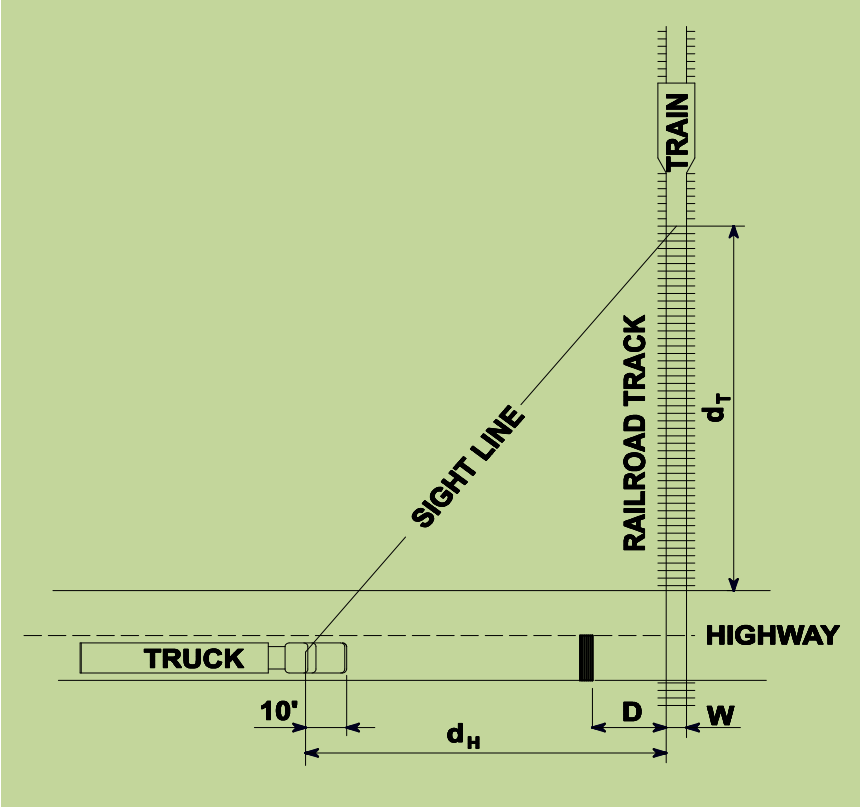
8. The minimum vertical clearance to structures passing over freeways should be at least ___ ft over the entire roadway width.

(A) 10.0
(B) 14.0
(C) 16.0
(D) 18.0

SOLUTION:
Reference Section 8.2.9, p. 8-4
Answer C

9. A truck is traveling toward a railroad / highway grade crossing at 55 mph. There are no train-activated warning devices. The grade crossing stop bar is located 20 ft from the nearside rail, and the truck driver is seated 10 feet back from the truck's front bumper. Assuming AASHTO-recommended design values for perception-reaction time, determine the required sight triangle distance (ft) along the highway for the truck to stop at the stop line for an approaching train:

(A) 505
(B) 515
(C) 522
(D) 530



SOLUTION:

For Case A condition, using Eqn 9-3 on p. 9-187,

$$d_H = A(V_v)(t) + \frac{BV_v^2}{a} + D + d_e$$

$$d_H = 1.47(55)(2.5) + \frac{1.075(55^2)}{11.2} + 20 + 10 = 522.5\ ft$$

Answer C

Workshop Problems

1. **Workshop Problem** - What is the overall length, (ft), of a "Double-Bottom Semitrailer/Trailer" (WB-67D)?

(A) 72.3
(B) 97.3
(C) 104.8
(D) 114.0

SOLUTION:

2. **Workshop Problem** - What is the rear overhang (measured from back axle of tandem axle assembly) of a Turnpike Double-Semitrailer?

(A) 3.0
(B) 4.5
(C) 5.0
(D) 6.0

SOLUTION:

3. **Workshop Problem** - What is the minimum turning radius, (ft), of a City Transit Bus (CITY-BUS) making a 180 degree turn?

(A) 22.3
(B) 24.5
(C) 37.8
(D) 41.6

SOLUTION:

4. **Workshop Problem** - The estimated crash rate per Million Vehicle-Miles of Travel on undivided rural roadways with a total of 20 Driveways per mile is most nearly:

(A) 2.5
(B) 3.5
(C) 4.5
(D) 5.5

SOLUTION:

5. **Workshop Problem** - A horizontal curve will be designed for a high-speed urban street with a design speed of 50 mph and a maximum superelevation rate of 4%. Using AASHTO criteria, the minimum rounded radius (ft) is most nearly:

(A) 1,050
(B) 1,190
(C) 926
(D) 711

SOLUTION:

6. **Workshop Problem** - A minivan is traveling along a level one lane street in Center City Philadelphia at 30 mph when suddenly a jogger runs out into the street 495 feet ahead of the vehicle. The travel lane is 12 ft wide and there are parked cars on both sides. What is the minimum sight distance (ft) required to avoid hitting the jogger?

(A) 220
(B) 275
(C) 330
(D) 490

SOLUTION:

7. **Workshop Problem** - Which of the following are appropriate options for the treatment of roadside obstacles?

I. Remove or redesign the obstacle so it can be safely traversed.
II. Relocate the obstacle to a point where it is less likely to be struck.
III. Reduce impact severity by using an appropriate breakaway device.
IV. Shield the obstacle with a longitudinal barrier or crash cushion.
V. Delineate the obstacle to make it more visible.
VI. Take no action.

(A) I, II, III, IV, and V only.
(B) I, III, IV, and V only
(C) I, III, IV, V, and VI only
(D) all six options

SOLUTION:

8. **Workshop Problem** - Frontage roads serve numerous functions, including controlling access to an arterial and segregating local traffic from higher speed through traffic. In urban areas a minimum spacing of ___ ft between arterial and frontage roads is desirable.

(A) 75
(B) 100
(C) 125
(D) 150

SOLUTION:

9. **Workshop Problem** - The **minimum** horizontal clear zone width (ft) for a low-speed rural collector is most nearly:

(A) 24
(B) 18
(C) 14
(D) 7

SOLUTION:

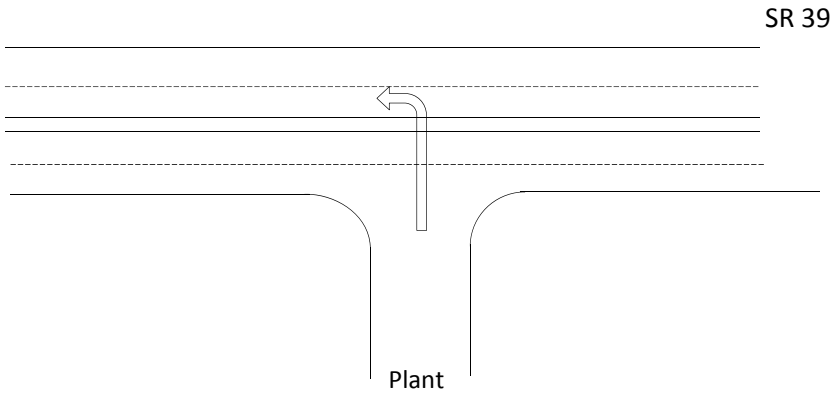
10. **Workshop Problem** - A passenger car is stopped at a stop sign, waiting to cross a two lane highway with 12-foot lanes and a design speed of 70 mph. What is the required design intersection sight distance (ft) for a P vehicle on a +2.5% approach making a crossing maneuver?

(A) 600
(B) 670
(C) 750
(D) 830

SOLUTION:

11. Workshop Problem - A manufacturer plans to build a new plant on SR 39, which is a windy, four-lane, undivided highway in the hills west of town. The plant will generate a significant amount of combination truck traffic. SR 39 has a design speed of 50 mph. In evaluating possible sites for the new plant, you consider the required intersection sight distance. What is the required intersection sight distance (ft) for left turns from the plant onto SR 39?

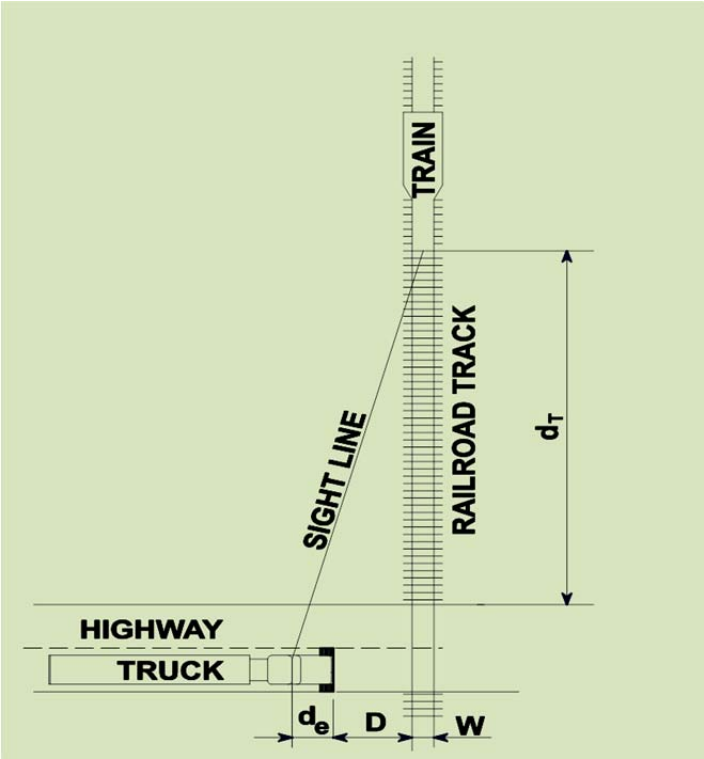
(A) 501
(B) 897
(C) 712
(D) 740



SOLUTION:

12. Workshop Problem - Given the physical layout of the grade crossing described below and assuming a train is approaching the crossing at 50 mph, determine the required sight triangle distance (ft) along the railroad for a truck stopped at the stop bar to safely depart and cross the track in front of the approaching train. Note that this truck has a maximum speed in first gear of 8.8 fps.

(A) 720
(B) 840
(C) 960
(D) 1275



SOLUTION:

22. **Workshop Problem** - You're traveling on an undivided highway in a suburban area. There are 20 access points per mile. What is most nearly the accident rate per Million Vehicle Miles of Travel?
    (A) 3
    (B) 4
    (C) 5
    (D) 6

SOLUTION:

Homework Problems

NOTE: Concepts of the most of the problems listed below are either discussed in the lectures or included in the Workshop Problems. These are extra problems. If your time permits, you can work on these problems also to strengthen your knowledge further.

1. **Homework Problem** - What is the overall height, (ft), of an Articulated Bus (A-BUS)?
   (A) 9.5
   (B) 10.0
   (C) 11.0
   (D) 12.0

   SOLUTION:

2. **Homework Problem** - What is the minimum turning radius, (ft), of an Interstate Semitrailer (WB-67) making a 180 degree turn?
   (A) 41.0
   (B) 42.9
   (C) 44.8
   (D) 45.2

   SOLUTION:

3. **Homework Problem** - What is the minimum turning radius, (ft), of a Motor Home (MH) making a 180 degree turn?
   (A) 15.4
   (B) 26.0
   (C) 36.0
   (D) 39.7

   SOLUTION:

4. **Homework Problem** - A horizontal curve on a two-lane rural highway has the following characteristics:

Design speed, V	60 mph
Radius (minimum)	1,091 ft
Coefficient of side friction	0.12
Lane width	12 ft

   The rate of superelevation required for this curve is most nearly:
   (A) 7%
   (B) 10%
   (C) 11%
   (D) 33%

   SOLUTION:

5. **Homework Problem** - Vehicle A is traveling west at 48 mph on a two lane rural highway. Vehicle B is also traveling west on the same highway at 75 mph and comes upon Vehicle A. The driver of Vehicle B trails Vehicle A for several miles, looking for an opportunity to pass. What is the required minimum passing sight distance?
   (A) 800
   (B) 900
   (C) 1000
   (D) 1200

   SOLUTION:

6. **Homework Problem** - A winding mountain road curves to the right on a three-centered horizontal compound curve. The curves are getting progressively sharper. The radius of the first curve is 1500 ft. What is the minimum radius, (ft), of the third curve?
   (A) 375
   (B) 500
   (C) 670
   (D) 750

   SOLUTION:

7. **Homework Problem** - For the third curve in the previous problem, what is the desirable arc length (ft)?
   (A) 120
   (B) 140
   (C) 180
   (D) 200

   SOLUTION:

8. **Homework Problem** - A proposed intersection, right turn ramp will carry predominantly P vehicles, but some consideration must be given to SU trucks. The pavement width is to be designed for one-lane, one-way operation with provisions for passing a stalled vehicle so traffic flow can be maintained at reduced speeds. The minimum radius on the inner edge of pavement is to be 75 ft and vertical curb is to be installed on both sides. What is the minimum required pavement width (ft)?
   (A) 18
   (B) 19
   (C) 20
   (D) 21

   SOLUTION:

9. **Homework Problem** - A freeway ramp has the following characteristics:

- Radius on inner edge of pavement equals 100 ft.
- One-lane, one-way operation with no provisions for passing a stalled vehicle
- Design traffic Condition A
- Barrier curb on both sides

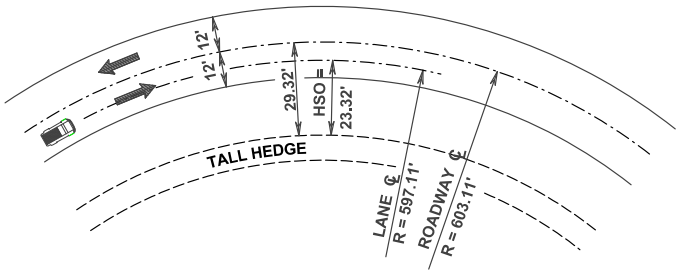
The ramp pavement width needed (ft) is most nearly:

(A) 15
(B) 16
(C) 17
(D) 18

SOLUTION:

10. **Homework Problem** - You are traveling on a two-lane highway that curves to your right. You are in the right lane. The highway centerline has a 9^0-30' degree of curvature. The lanes are each 12-feet wide and an 8-foot tall hedge is runs along the right side of the highway, exactly 29.32 ft to the right of the highway centerline. Based on this data, which of the following is the maximum safe design speed for this highway:

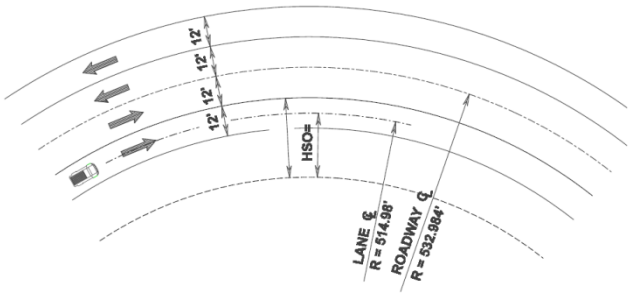
(A) 38.7
(B) 41.5
(C) 42.8
(D) 43.2



SOLUTION:

33. Homework Problem - A four-lane undivided highway has a design speed of 40 mph, and curves to the right. The lanes are 12 ft wide. The centerline Degree of Curvature, D, is 10^0 45'. Determine the required clearance (or HSO) from the centerline of the right-most lane to the closest horizontal sightline obstruction based on Stopping Sight Distance criteria:

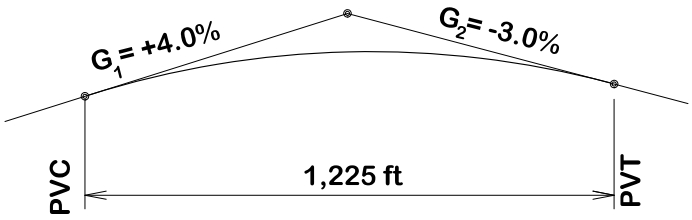
(A) 20
(B) 21
(C) 22
(D) 23



SOLUTION:

34. Homework Problem - According to AASHTO, the passing sight distance (ft) for the following vertical curve is most nearly:

(A) 1,285
(B) 800
(C) 780
(D) 700



SOLUTION:

35. Homework Problem - What is the maximum grade on an urban collector road with a design speed of 45 mph in mountainous terrain?

(A) 11%
(B) 12%
(C) 13%
(D) 14%

SOLUTION:

36. Homework Problem - What is the maximum grade on a rural arterial with a design speed of 60 mph in rolling terrain?

(A) 1%
(B) 2%
(C) 3%
(D) 4%

SOLUTION:

37. Homework Problem - What is the maximum grade on an urban arterial with a design speed of 50 mph in mountainous terrain?

(A) 7%
(B) 8%
(C) 9%
(D) 10%

SOLUTION:

38. Homework Problem - Which of the following are typical characteristics of a modern roundabout in the United States:

I Yield on entry
II Clockwise circulation
III Deflection of entering traffic
IV Central island

(A) I, II, III
(B) I, II, IV
(C) I, III, IV
(D) I, II, III, IV

SOLUTION:

39. **Homework Problem** - What is the recommended minimum length, L (ft), between successive entrance ramp terminals on a Freeway Distributor Road (FDR)?
    (A) 400
    (B) 500
    (C) 600
    (D) 800

    SOLUTION:

40. **Homework Problem** - What is the recommended minimum length, L (ft), between entrance and exit ramps (other than cloverleaf loop ramps) terminals on a full freeway at a service to service interchange?
    (A) 1000
    (B) 1600
    (C) 1800
    (D) 2000

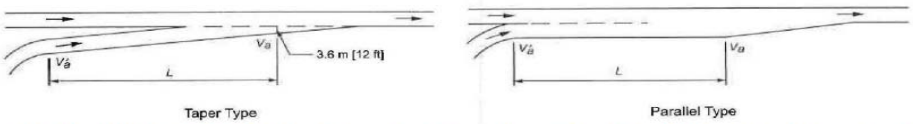
    SOLUTION:

41. **Homework Problem** - A single-lane entrance ramp joins a tangent section of freeway mainline as a taper-type entrance. The entrance ramp design speed is 40 mph, and the highway design speed is 60 mph. The grade is +2.0%. The minimum acceleration length, L (ft), needed for the entrance is most nearly:
    (A) 130
    (B) 420
    (C) 550
    (D) 1600

    SOLUTION:

U.S. Customary										
Acceleration Length, L (ft) for Entrance Curve Design Speed (mph)										
Highway		Stop Condition	15	20	25	30	35	40	45	50
Design Speed, V (mph)	Speed Reached, V_a (mph)	and Initial Speed, V'_a (mph)								
		0	14	18	22	26	30	36	40	44
30	23	180	140	—	—	—	—	—	—	—
35	27	280	220	160	—	—	—	—	—	—
40	31	360	300	270	210	120	—	—	—	—
45	35	560	490	440	380	280	160	—	—	—
50	39	720	660	610	550	450	350	130	—	—
55	43	960	900	810	780	670	550	320	150	—
60	47	1200	1140	1100	1020	910	800	550	420	180
65	50	1410	1350	1310	1220	1120	1000	770	600	370
70	53	1620	1560	1520	1420	1350	1230	1000	820	580
75	55	1790	1730	1630	1580	1510	1420	1160	1040	780

Note: Uniform 50:1 to 70:1 tapers are recommended where lengths of acceleration lanes exceed 1,300 ft.



Taper Type Parallel Type

Table 10-3. Minimum Acceleration Lengths for Entrance Terminals with Flat Grades of Two Percent or Less.