Transportation Depth Topics

School of PE

Workshop Solutions
Set 2

Code: CITES-D **Spring** **2015**

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

This is a Multilane Highway Problem

Step 1 – Compute Free Flow Speed – Given as 46 mi/h

Step 2 – Convert volume to flow rate

$$v_p = \frac{V}{(PHF)(N)(f_{HV})(f_p)}$$

Where:

$V = 1{,}900\ vph; \quad PHF = 0.90; \quad N = 2; \quad f_p = 1.0$

For the upgrade, use specific grade tables in Exhibits 14-13 and 14-14

$$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)} = \frac{1}{1 + 0.13(2.0 - 1) + 0.02(3.0 - 1)} = 0.85$$

$$v_p = 1{,}236\ pcphpl$$

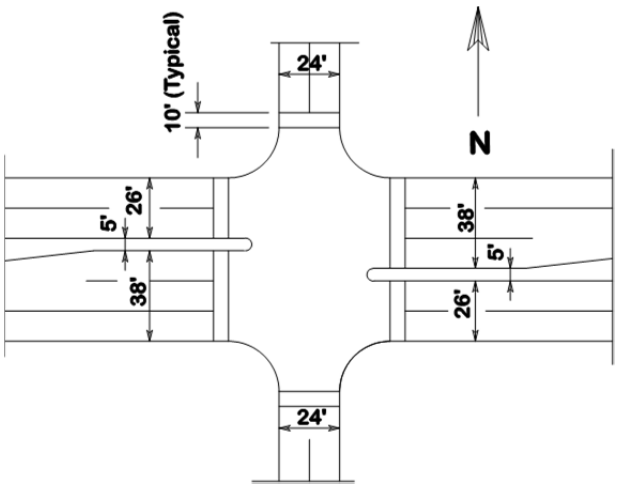
Step 3: Determine LOS

$$Density = \frac{1236}{46} = 26.9\ pc/mi/ln$$

LOS = D

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

Per HCM Eq. 18-66, the minimum green time for a phase is estimated as:

$$t_{ps} = 3.2 + \frac{L}{S_p} + 0.27(N_{ped}) \; for \; W_E \leq 10 \; ft$$

From the above figure, the N-S crosswalk length is 69 ft.

$$t_{ps} = 3.2 + \frac{69}{4.0} + 0.27(10) = 23.15 \; sec$$

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) Per HCM Exhibit 18-4:

EB – LOS B; WB – LOS C; NB – LOS E; SB – LOS C

b)

$$Intersection\ Delay, \qquad d_I = \frac{\Sigma(d_A)(V_A)}{\Sigma v_A}\ (s/veh)$$

$$d_I = \frac{\Sigma[(16.2 \times 491) + (23.6 \times 672) + (58 \times 825) + (32 \times 858)]}{(491 + 672 + 825 + 858)}$$

$$d_I = 34.8\ sec.$$

c) Per HCM Exhibit 18-4, 34.8 sec delay is equivalent to LOS 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

Using Eqn 18-17 (modified) from HCM,

$$C = \frac{L \times X}{[X - (v/s)_1 - (v/s)_2 - (v/s)_3 - \ldots (v/s)_n]} = \frac{8 \times 0.9}{[0.9 - 0.37 - 0.42]} = 66 \text{ sec}$$

Where:

$(v/s)_1 = 890/2400 = 0.37$

$(v/s)_2 = 750/1800 = 0.42$

Total Lost time: L = 2 x 4 = 8 sec / cycle

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

Using Eqn 18-17 (modified) from HCM, (Use Xc = 1.00 for min cycle length)

$$C_{min} = \frac{LX_c}{X_c - \Sigma\left(\frac{v}{s}\right)} = \frac{8(1.0)}{1.0 - 0.46 - 0.29} = 32\ sec$$

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

Using equation 23-1 of HCM,

$$W_E = W_T - W_o = 20.0 - (4.0 + 1.5) = 14.5\ ft$$

Using equation 23-3 in HCM,

$$v_p = \frac{v_{15}}{15 \times W_E} = \frac{1{,}600}{15 \times 14.5} = 7.35\ \ p/min\ /ft$$

Using Exhibit 23-1 in HCM, answer is LOS C.

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:

According to the Section 2E.32 Interchange Classification, this is a category (b) Major Interchange. See Table 2E-4. *Minimum Letter and Numeral Sizes for Freeway Guide Signs According to Interchange Classification*. The required letter size is **20 inches.**

The correct answer is D

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:
The situation described above requires design of a guide sign for a conventional road. See Section 2D.06 Size of Lettering. "…on urban streets with speeds of 25 mph or less, the principal legend shall be in letters at least 4 in in height for all upper-case letters, or a combination of 4 inches in height for upper-case and three inches in height for lower-case letters." Therefore the required letter size is **4.0 inches**

The correct answer is C

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:
According to Section 4E.02, Meaning of Pedestrian Signal Head Indications, a flashing WALKING PERSON indication has no meaning and shall not be used

The correct speed is D.

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 85th 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:
See Figure 3B-14, Examples of Applications of lane-Reduction Transitions Markings.

$$L = \frac{WS^2}{60} \; for\ speeds\ of\ less\ than\ 45\ mph, where:$$

$$L = Length\ of\ taper\ in\ feet$$

$$S = Posted, 85th\ percentile, or\ statutory\ speed\ in\ mph$$

$$W = Offset\ in\ feet$$

$$L = \frac{WS^2}{60} = \frac{(12)(40)^2}{60} = 320\ ft$$

The correct speed is C

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:

See Table 2C-4, Guidelines for Advance Placement of Warning Signs. The situation described is Condition A: Speed reduction and lane changing in heavy traffic. For an 85th percentile speed of 40 mph, the advance placement distance is **670 ft.**

The correct speed is A.

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:

This problem involves the placement of a delineator panels on a horizontal curve. Refer to Table 3F-1. First determine the radius of a 14^0 curve.

$$R = \frac{5729.578}{D} = \frac{5729.578}{14} = 409.25\ ft$$

Calculate the appropriate spacing, S, using the formula:

$$s = 3\sqrt{R - 50} = 3\sqrt{(409.25 - 50)} = 56.86;\ say\ 55\ ft$$

The correct speed is A.

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:

See Table 2C-4, Guidelines for Advance Placement of Warning Signs. The situation described is Condition B: Deceleration to the listed advisory speed (mph) for the condition. For an 85th percentile speed of 60 mph, the advance placement distance is **400 ft**.

The correct speed is C.

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:

See Section 4B.03 Advantages and Disadvantages of Traffic Control Signals. The installation of a new traffic control signal at an existing intersection can cause a significant increases in the frequency of collisions (especially rear-end collisions).

The correct answer is C

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:

See Section 4C.01 Studies and Factors for Justifying Traffic Control Signals.

The correct answer is A

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

   See Table 3-1, p. 3-3 and Table 3-2, p. 3-4

   From Table 3-1, for 65 MPH, ADT, 8800, Backslopes of 1V:6H gives a range of 28 to 30 feet

   Since the poles are on the right side road on a curve to the left, an adjustment factor of 1.3 should be selected from Table 3-2. After multiplying by the factor, the range is 36.4 to 39 ft.

   Correct Answer is D

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

   See Figure 3-7, p. 3-10

   The 1:4 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.

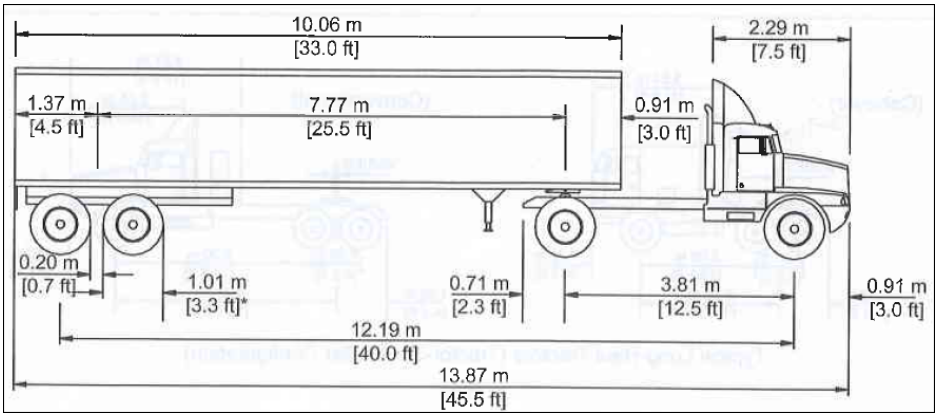
1. What is the overall height, (ft), of an Articulated Bus (A-BUS)?

(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

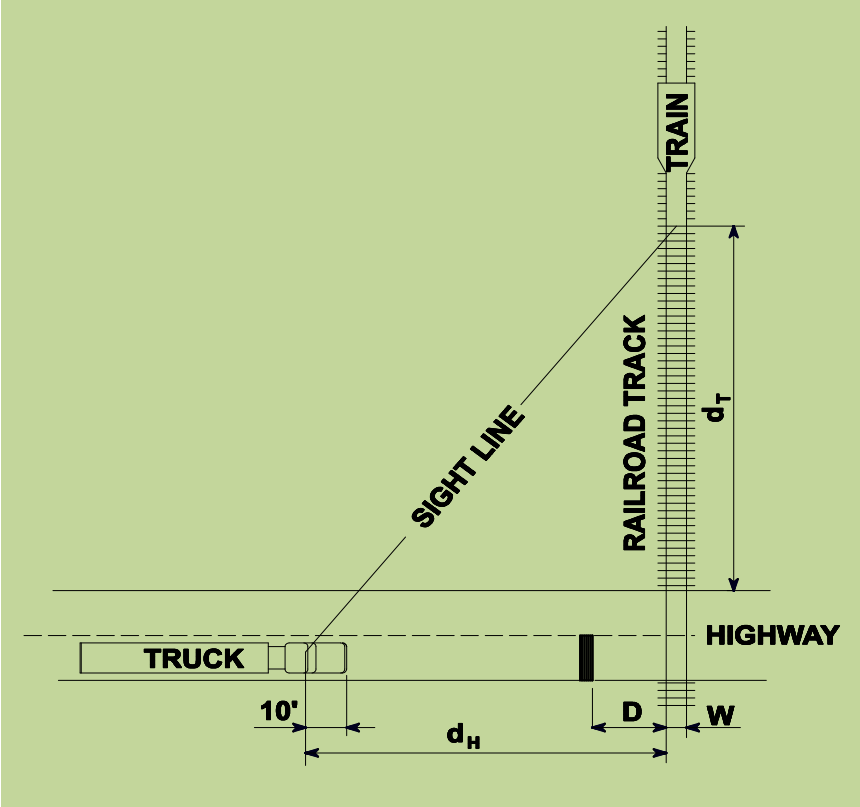
8. The minimum vertical clearance to structures passing over freeways should be at least ___ ft over the entire roadway width.

(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:
Reference Table 2-1b, p. 2-4
Answer A

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

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:
Reference Figure 2-6, p. 2-15
Answer D

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:

Reference Figure 2-33, p 2-76

Answer B

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:

Reference Table 3-7, p 3-32

Answer C

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:

Reference Table 3-3, p. 3-7

Answer D

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:
Reference 2nd Paragraph, p 4-30
Answer D

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:
Reference Paragraph 4.12, Frontage Roads, p. 4-36
Answer D

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:

Reference Section 6.2.4, p. 6-8
Answer D

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?

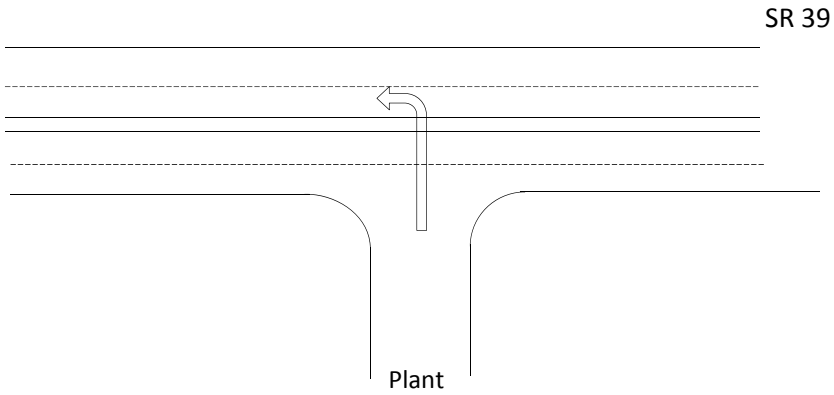
(A) 600
(B) 670
(C) 750
(D) 830

SOLUTION:

Reference p 9-40 and 9-41
Answer B

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:

Reference Table 9-5, p. 9-37

$ISD = 1.47Vt_g$

V = 50 mph;

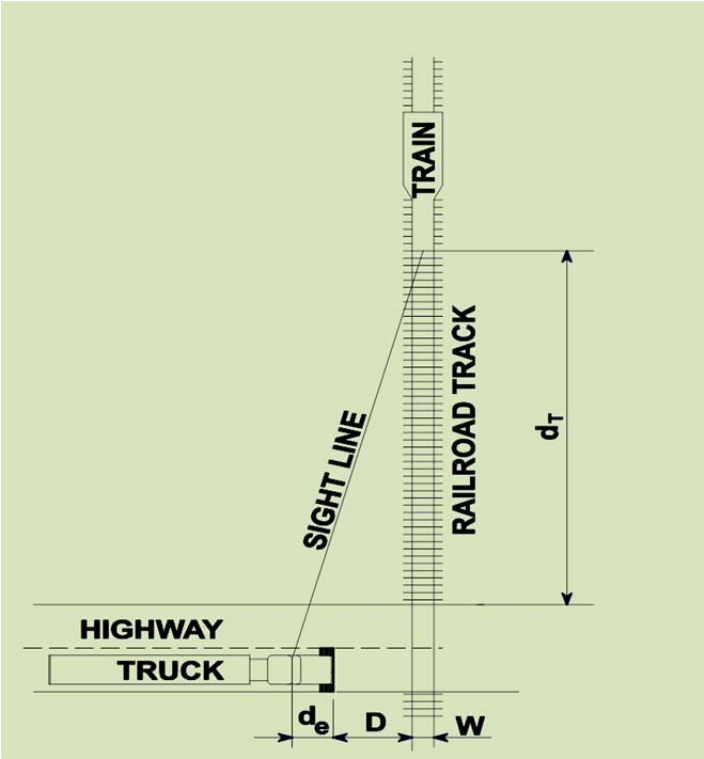
t_g = 11.5 sec + 0.7 sec = 12.2 sec (NOTE: 0.7 sec is for crossing the second lane for combination truck)

ISD = 1.47 * 50 * 12.2 = 896.7 ft

Answer B

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:

For Case B, using Eqn. 9-4, p. 9-189

$$d_T = A(V_T)\left(\frac{V_G}{a_1} + \frac{L+2D+W-d_a}{V_G} + J\right)$$ AASHTO GB Equa.9.4

$$d_T = 1.47(50)\left(\frac{8.8}{1.47} + \frac{73.5+2(15)+5-26.3}{8.8} + 2.0\right) = 1274ft$$

Answer D

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:

Reference Figure 2-32

Answer D

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

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:
   Reference Figure 2-15, p. 2-24
   Answer C

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:

Reference Figure 2-20, p. 2-29
Answer D

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:
Reference Table 3-7, p 3-32

$$R = \frac{V^2}{(15)(0.01e_{max} + f_{max})}$$

$$1{,}091 = \frac{60^2}{(15)[0.01(e) + 0.12]}$$

$$e = 10\%$$

Answer B

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:
Reference Table 3-4, p. 3-9
Answer C *

* We need to use "Passed Vehicle" as a basis to find PSD. As per the table, for 48 mph speed of "Passed Vehicle" (Vehicle A), Passing Vehicle speed is 60 mph. In our problem, passing vehicle (Vehicle B) is travelling at 75 mph. However, in reality, when Vehicle B approaches Vehicle A, Vehicle B has to slow down and trail Vehicle A for a distance. As per the table, it slows down to 60 mph before it passes Vehicle A. Therefore, our value 1,000 ft came from the row 48 mph for Passed Vehicle and 60 mph for Passing Vehicle.

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:
Reference p 3-84
Answer C *

* This problem is related to open highway (not an intersection). We have to use

1.5:1 ratio. Therefore, second curve is 1500/1.5 = 1,000 ft. Third curve is 1,000/1.5 = 667 ft.

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:
Reference p 3-84

Answer D

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:
Reference Table 3-29, p. 3-103

Answer C *

* Same problem is in the Refresher Notes of the regular class.

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

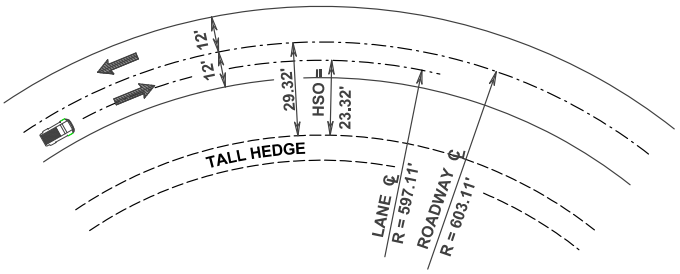
SOLUTION:

Reference Table 3-29, p 3-103

Answer C

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:

Reference p. 3-4 and 3-109

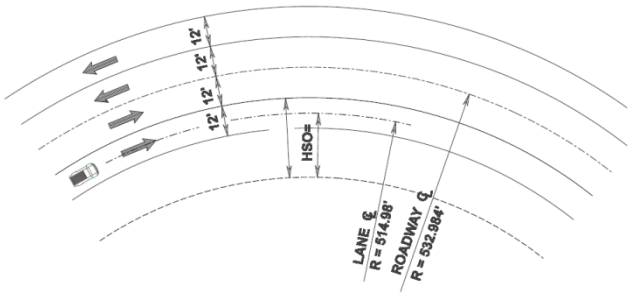
Use the following solution procedure:

1. Convert Degree of Curvature (9^0-30') to the equivalent radius: 603.11'
2. Determine the radius of the centerline, right-most lane: 597.11'
3. Determine actual HSO distance to the tall hedge: 29.32' – 6' = 23.32'
4. Plug the above values of R and HSO into CERM Eq. 79-44 and solve for S.
5. You should find S =335'.
6. Compare this calculated S to the S values on CERM Table 79-2 to find the maximum safe design speed of 42.8 mph.

Answer C

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:

Reference p. 3-4 and 3-109

Use the following solution procedure:

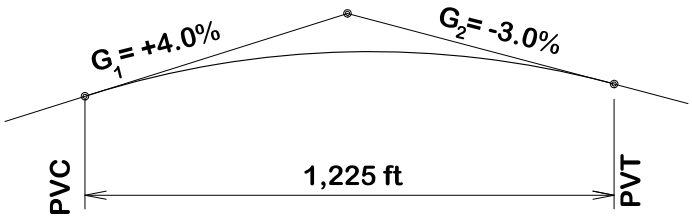
1. Convert Degree of Curvature (10^0-45') to the equivalent radius: 532.98 ft.
2. Determine the radius of right-most lane centerline: 532.98 – 18 = 514.98 ft.
3. Determine Stopping Sight Distance, $S_{40\ mph}$ = 305 ft.
4. Determine HSO distance using CERM Eq. 79-45:

$$HSO = R\left(1 - \cos\left(\frac{28.65(S)}{R}\right)\right) = 514.98\left(1 - \cos\left(\frac{28.65(305)}{514.98}\right)\right) = 22.18$$

Answer C

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:

Reference p 3-156

$Where\ S < L,\ \ L = \frac{AS^2}{2{,}800}$

$1{,}225 = \frac{|-3.0 - (4.0)|S^2}{2{,}800} = \frac{7S^2}{2{,}800}$

$S = 700\ ft$

$Verify\ S < L \Rightarrow 700\ ft < 1{,}000\ ft\ \ \ OK!$

Answer D

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:

Reference Table 6-8, p 6-12

Answer A

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:

Reference Table 7-2, p 7-4
Answer D

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:

Reference Table 7-4, p 7-29
Answer C

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:

Reference Section 9.10.1, p. 9-169

Answer C

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:
    Reference Table 10-68 p 10-106
    Answer D

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:
    Reference Table 10-68 p 10-106
    Answer B

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:
    Reference Table 10-3, p 10-110 (copy is provided below)

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.

Answer C