NCEES
advancing licensure for engineers and surveyors

PE

civil: transportation

practice exam

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About NCEES

NCEES is a nonprofit organization made up of the U.S. engineering and surveying licensing boards in all 50 states, the U.S. territories, and the District of Columbia. We develop and score the exams used for engineering and surveying licensure in the United States. NCEES also promotes professional mobility through its services for licensees and its member boards.

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The PE Civil: Transportation exam is computer-based. It contains 80 questions and is administered year-round via computer at approved Pearson VUE test centers. A 9-hour appointment time includes a tutorial, the exam, and a break. You have 8 hours to complete the actual exam.

In addition to traditional multiple-choice questions with one correct answer, the exam uses common alternative item types such as

- Multiple correct options—allows multiple choices to be correct
- Point and click—requires examinees to click on part of a graphic to answer
- Drag and drop—requires examinees to click on and drag items to match, sort, rank, or label
- Fill in the blank—provides a space for examinees to enter a response to the question

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Results for computer-based exams are typically available 7–10 days after you take the exam. You will receive an email notification from NCEES with instructions to view your results in your MyNCEES account. All results are reported as pass or fail.

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Visit us at ncees.org/exams for updates on everything exam-related, including specifications, exam-day policies, scoring, and corrections to published exam preparation materials. This is also where you will register for the exam and find additional steps you should follow in your state to be approved for the exam.

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PE CIVIL: TRANSPORTATION PRACTICE EXAM

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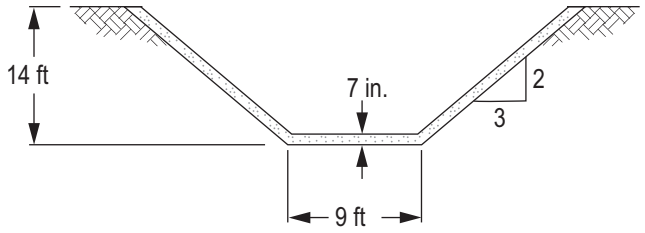
1. A 227-ft length of canal is to be lined with concrete for erosion control. With 12% allowance for waste and overexcavation, the volume (yd^3) of concrete that must be delivered is most nearly:



LINED LENGTH = 227 ft

- ○ A. 234
- ○ B. 280
- ○ C. 292
- ○ D. 327

2. The budgeted labor amount for an excavation task is $4,000. The hourly labor cost is $50 per worker, and the workday is 8 hours. Two workers are assigned to excavate the material. The time (days) available for the workers to complete this task is most nearly:

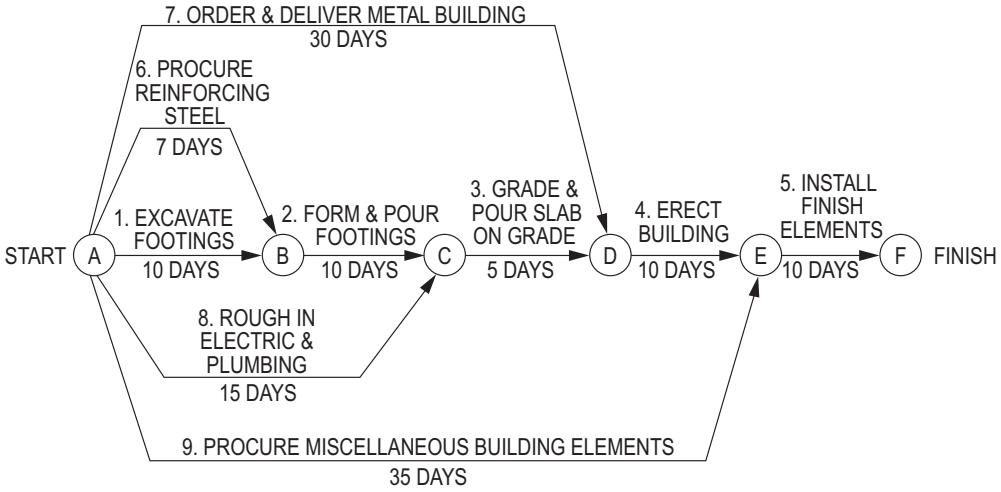
- ○ A. 3
- ○ B. 4
- ○ C. 5
- ○ D. 12.5

3. A bridge is to be jacked up to replace its bearings. The design requires a hydraulic ram with a minimum capacity of 1,000 kilonewtons (kN). The hydraulic rams that are available are rated in tons (2,000 lb/ton). The **minimum** size (tons) ram to use is most nearly:

- ○ A. 1,110
- ○ B. 250
- ○ C. 150
- ○ D. 100

PE CIVIL: TRANSPORTATION PRACTICE EXAM

4. A CPM arrow diagram is shown below. Nine activities have been estimated with durations ranging from 5 to 35 days. The minimum time (days) required to finish the project is most nearly:



- ○ A. 40
- ○ B. 42
- ○ C. 45
- ○ D. 50

5. A paving company purchased an asphalt paving roller for $350,000 in 2008. Assuming an average inflation rate of 3.5%, the actual replacement cost for an equivalent roller machine in the year 2025 would be $ _____.

Enter your response in the blank.

6. A track loader has an initial cost of $75,000 and a salvage value of $10,000 at the end of its expected life of 10 years. Based on the straight-line method of depreciation, at the end of the track loader's 8th year, its book value is most nearly:

- ○ A. $10,000
- ○ B. $15,000
- ○ C. $23,000
- ○ D. $48,750

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7. The total cost to construct a new highway is $6,987,500. The annual debt service to retire a bond in this amount over a 25-year period at 4% interest is most nearly:

- ○ A. $290,680
- ○ B. $363,350
- ○ C. $372,550
- ○ D. $447,270

8. The following information applies to a four-lane urban freeway.

Volume = 2,400 vph (in one direction)
Peak-hour factor = 0.90
Base free-flow speed = 60 mph
5% truck traffic in peak hour
12-ft lanes
10-ft outside shoulders
3 interchanges in 6 miles
Level terrain
No recreational vehicles

The level of service (LOS) for the freeway is most nearly:

- ○ A. LOS A
- ○ B. LOS B
- ○ C. LOS C
- ○ D. LOS D

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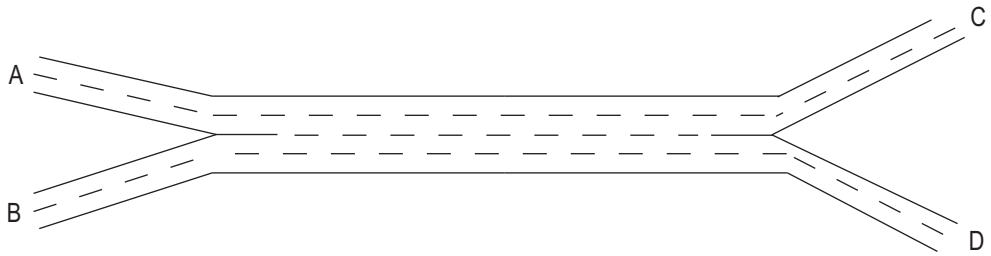
9. The figure shows a major weave segment of a freeway. The following data apply:

Flow rate A-C = 4,200 pcph
Flow rate B-C = 600 pcph
Flow rate A-D = 500 pcph
Flow rate B-D = 400 pcph

If the mean speed of the traffic in the weave segment is 56 mph and the segment is very long, the density (pc/mile/lane) in the middle of the segment is most nearly:



- ○ A. 25
- ○ B. 28
- ○ C. 32
- ○ D. 34

10. For a lane group at a signalized intersection, which of the following factors will change the saturation flow rate from the base saturation flow rate provided in the *Highway Capacity Manual*?

- ○ A. Lane widths of 11 ft
- ○ B. Level terrain
- ○ C. Peak hour factor of 0.92
- ○ D. Inclusion of left turns with protected phasing

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11. The one-lane approach to an intersection has a 27-sec green time, a 3-sec clearance time including all red time, and a 90-sec cycle. The saturation headway is 2.4 sec/vehicle, start-up lost time is 2 sec per phase, and the clearance lost time is 1 sec per phase. The capacity (vph) for this approach movement is most nearly:

- ○ A. 840
- ○ B. 825
- ○ C. 675
- ○ D. 450

12. A speed study concludes that the 85th percentile speed of free-flowing traffic is 56.2 mph. Which are the best posted speed limit signs that meet the guidance for speed limit signs?

Select the **two** that apply.

- ☐ A. 50 mph
- ☐ B. 55 mph
- ☐ C. 56 mph
- ☐ D. 60 mph
- ☐ E. 65 mph

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13. Continuous daily traffic counts on an urban arterial street (Street A) were recorded as shown in the following table:

Daily Traffic Counts on Urban Arterial Street A	
Day	**24-hour Volume**
Sunday	6,950
Monday	9,450
Tuesday	7,340
Wednesday	10,300
Thursday	9,850
Friday	11,250
Saturday	8,450

On a similar arterial street (Street B) in the same city, a total of 7,450 vehicles were counted in a 24-hour period on a Wednesday. The estimated average daily traffic volume for Street B for the week is most nearly:

- ○ A. 6,570
- ○ B. 7,080
- ○ C. 7,450
- ○ D. 8,450

14. A multiple regression analysis for trip generation purposes shows the following relationship for the number of trips per household:

$$\text{Trips generated per household per day} = 0.58 + 1.5P + 2.2A$$

where:

P = number of persons per household
A = number of autos per household

If a zone under study contains 600 households with an average of 4.1 persons and 2.3 autos for each household, the number of trips generated per day is _____.

Enter your response in the blank.

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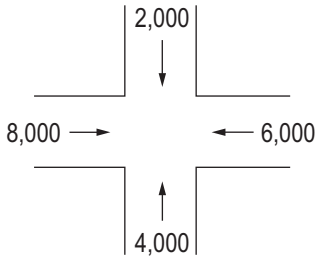
15. An intersection had 25 reported traffic accidents from January 1 through September 30. The ADT for this intersection is shown in the following figure. The accident rate per million entering vehicles (RMEV) for this intersection is most nearly:



- ○ A. 4.6
- ○ B. 3.4
- ○ C. 0.5
- ○ D. 0.2

16. A 10-ft-wide off-street pedestrian walkway has an effective walkway width of 6.5 ft. The peak 15-min pedestrian flow is 1,200 pedestrians. The average pedestrian speed is 280 ft/min. The platoon-adjusted LOS is most nearly:

- ○ A. LOS B
- ○ B. LOS C
- ○ C. LOS D
- ○ D. LOS E

17. A segment of a roadway has an average daily traffic of 12,350 and an annual growth rate of 7%. If this rate of traffic volume growth continues, the average daily traffic volume (vpd) in 10 years will be most nearly:

- ○ A. 8,650
- ○ B. 17,650
- ○ C. 21,000
- ○ D. 24,300

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18. Match each value to its corresponding **minimum** horizontal clear-zone width (ft) for the roadway characteristics shown. Some values will be used more than once.

DESIGN SPEED (mph)	ADT	SLOPE	WIDTH
30	400	1V:4H foreslope	
70	13,000	1V:3H backslope	
50	4,000	1V:8H foreslope	
60	1,200	1V:4.5H backslope	
45	7,000	1V:4H foreslope	
35	1,000	1V:6H foreslope	

24

22

16

10

7

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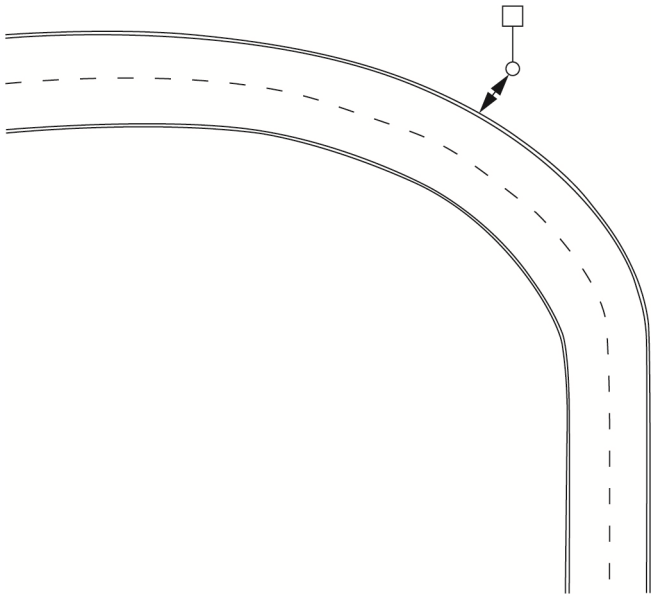
19. An urban roadway section is curbed and enters a horizontal curve as shown. According to AASHTO, the recommended lateral offset (ft) from the face of the curb to a rigid object on the outside of the curve is most nearly:



- ○ A. 1.5
- ○ B. 4
- ○ C. 6
- ○ D. 12

20. A vehicle weighing 2,000 lb traveling at a speed of 45 mph strikes a sand-filled barrel crash cushion system. The front barrel weighs 600 lb. The speed (mph) of the vehicle after impact with the front barrel is most nearly:

- ○ A. 35
- ○ B. 32
- ○ C. 14
- ○ D. 10

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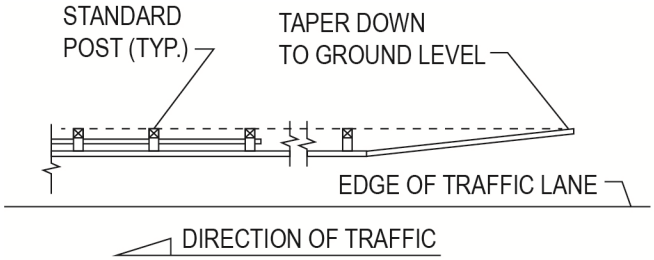
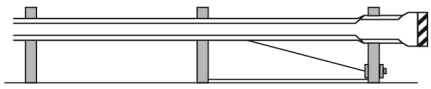
21. Which of the following end treatments are **not** crashworthy?

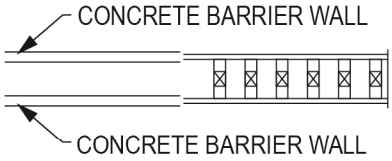
Select the **two** that apply.



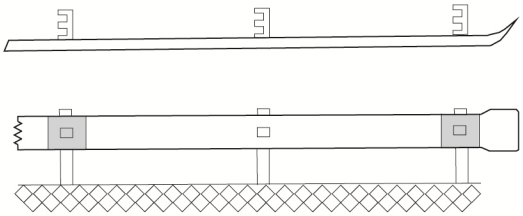
TURNDOWN-STYLE END TERMINAL



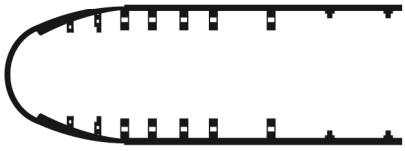
SLOTTED RAIL TERMINAL



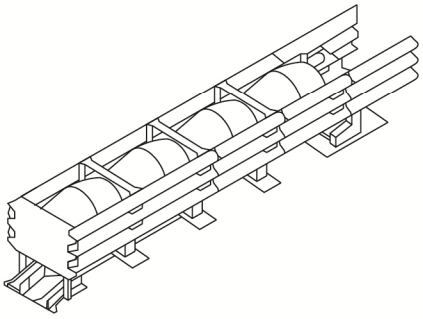
IMPACT TERMINAL



FLARED END TERMINAL



THRIE-BEAM BULLNOSE



INERTIAL BARREL ARRAY

- ☐ A. Turndown-style end terminal
- ☐ B. Slotted rail terminal
- ☐ C. Impact attenuator
- ☐ D. Flared end terminal
- ☐ E. Thrie-beam bullnose
- ☐ F. Inertial barrel array

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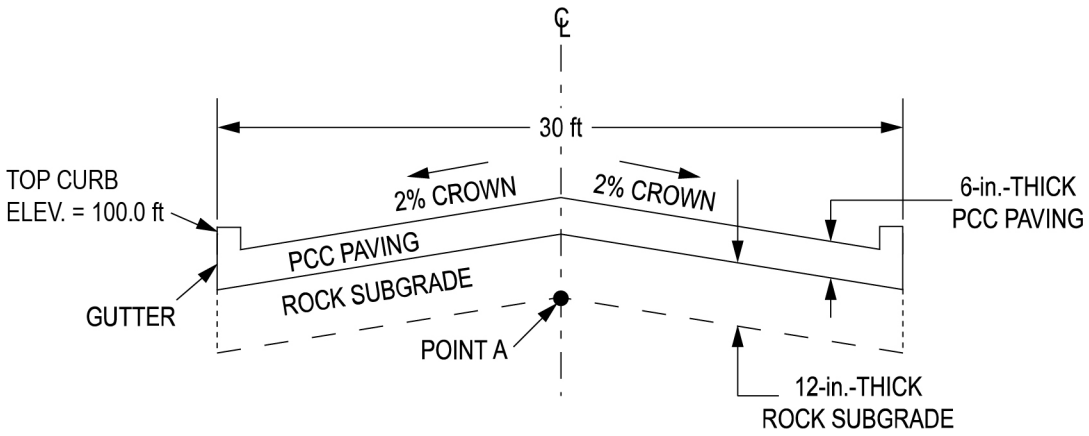
22. A freeway off-ramp has a design speed of 50 mph. How wide should the paved right shoulder be?

- ○ A. 1 to 6 feet
- ○ B. 2 to 4 feet
- ○ C. 6 to 10 feet
- ○ D. 8 to 10 feet

23. PCC paving is planned over a 12-in.-thick rock subgrade. Given the information on the figure and assuming the curb height is 6 in. above the gutter, the elevation (ft) of Point A is most nearly:



- ○ A. 98.3
- ○ B. 98.6
- ○ C. 98.8
- ○ D. 99.3

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24. For a project that includes curbs and adjacent sidewalks, the maximum curb ramp grade to meet Americans with Disabilities Act (ADA) requirements is:

- ○ A. 8.33%
- ○ B. 5.00%
- ○ C. 2.00%
- ○ D. 0.60%

25. Effective pedestrian safety and travel along highways and streets strategies include which of the following measures?

Select the **four** that apply.

- ☐ A. Curb extensions (bulb-outs) at intersections
- ☐ B. The assumption of higher walking speeds
- ☐ C. Accessible pedestrian signals
- ☐ D. Median refuge islands
- ☐ E. Repetition and redundancy in design and signing

26. The following information is for a proposed horizontal curve in a new subdivision:

PI station = 12+40.00
Degree of curve = 10°
Deflection angle = 12°30′

The station of the PT is most nearly:

- ○ A. 12+79.80
- ○ B. 12+80.10
- ○ C. 13+02.00
- ○ D. 13+64.75

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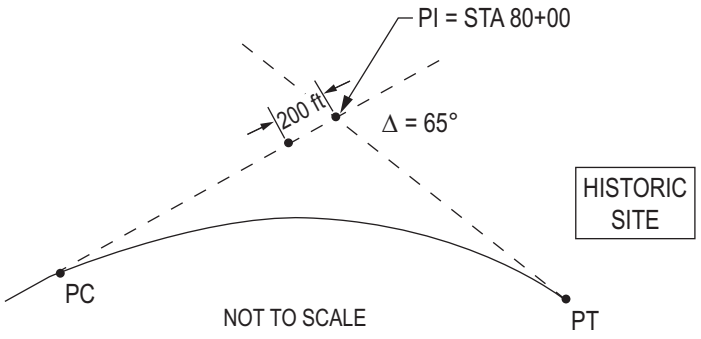
27. An existing highway has a historic site located at the PT of an existing curve with a PI located at Station 80+00, an external angle of 65°, and a radius of 1,200 ft. The curve must be relocated, moving the PI to Station 78+00. The external angle and the PC will remain the same. The radius (ft) of the new curve is most nearly:



- ○ A. 263
- ○ B. 314
- ○ C. 886
- ○ D. 1,200

28. An alert driver with a perception-reaction time of 2.5 sec is driving at the posted speed of 45 mph and must stop suddenly to avoid an obstacle in the roadway. An impaired driver with a perception-reaction time of 3.5 sec is traveling 10 mph over the speed limit. The increase in the distance (ft) traveled by the impaired driver before the brakes are applied is most nearly:

- ○ A. 37
- ○ B. 66
- ○ C. 118
- ○ D. 283

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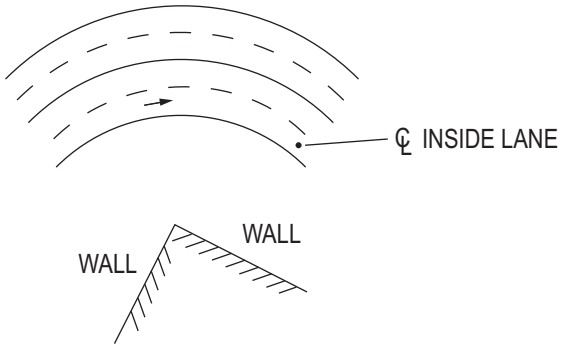
29. A section of a four-lane undivided highway forms a horizontal curve with a radius of 800 ft for the centerline of the inside lane. The highway is flat at this section and has a design speed of 45 mph. An architectural wall is being constructed by a local community center as shown in the figure. Assume a brake reaction time of 2.5 sec and a deceleration rate of 11.2 ft/sec^2. The minimum distance (ft) that the architectural wall can be constructed from the centerline of the inside lane of the curve based on sight distance is most nearly:



NOT TO SCALE

- ○ A. 15
- ○ B. 21
- ○ C. 28
- ○ D. 38

30. 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%

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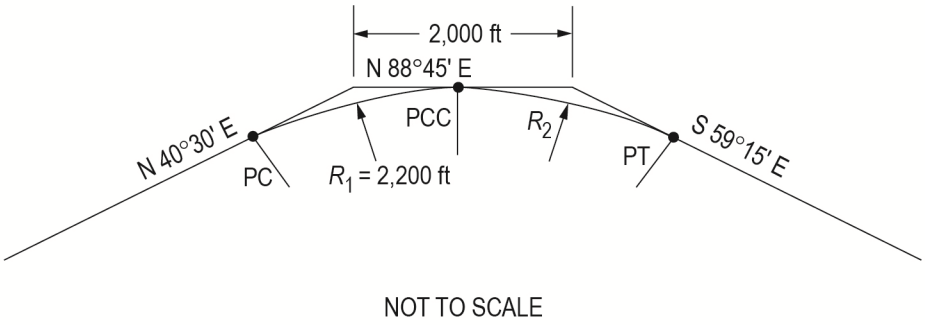
31. A four-lane undivided rural roadway is crowned at the centerline. Assume a 35-mph design speed, 2% crown, and 12-ft-wide lanes. The distance (ft) required to transition the roadway to a full 4.2% superelevation rate is most nearly:

- ○ A. 80
- ○ B. 120
- ○ C. 180
- ○ D. 240

32. A compound curve is shown in the figure. The length of the radius (ft) of the second curve, R_2, is most nearly:



NOT TO SCALE

- ○ A. 3,490
- ○ B. 3,540
- ○ C. 3,850
- ○ D. 4,240

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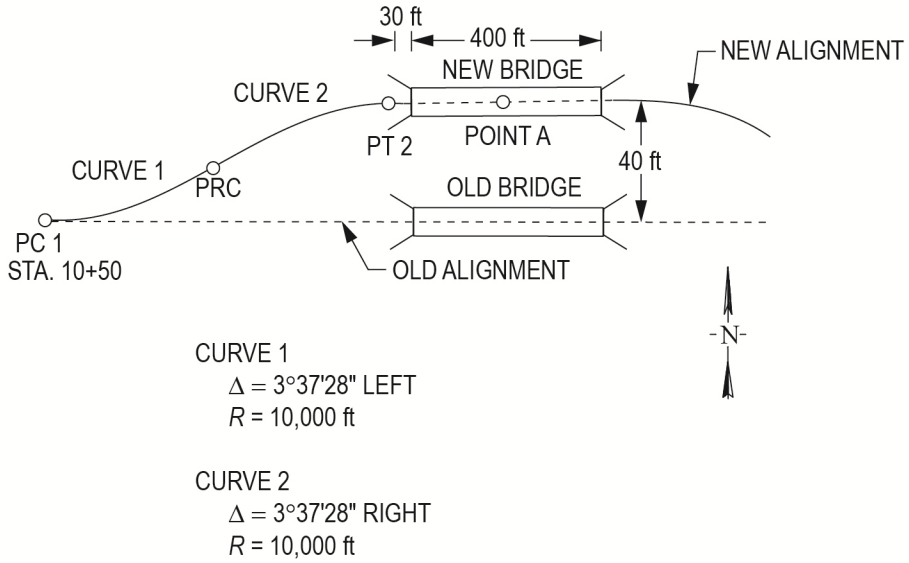
33. A set of reverse curves is used in the construction of a new 400-ft-long bridge on an offset alignment. The west end of the new bridge will be 30 ft from PT 2. If the station of PC 1 is 10+50, the station at the center of the new bridge (Point A) is most nearly:



CURVE 1
$\Delta = 3°37'28"$ LEFT
$R = 10{,}000$ ft

CURVE 2
$\Delta = 3°37'28"$ RIGHT
$R = 10{,}000$ ft

- ○ A. Station 14+95
- ○ B. Station 19+15
- ○ C. Station 23+15
- ○ D. Station 25+45

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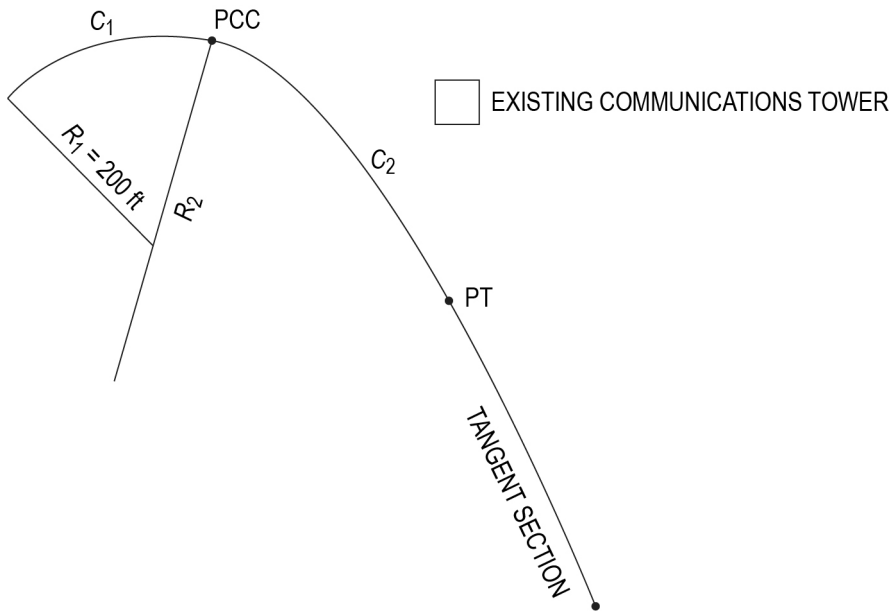
34. On a ramp, a compound curve of maximum radius is required to avoid an existing communications tower between a tangent segment and a curve with a 200-ft radius. Based on the AASHTO-recommended ratio of compound curve radii, the minimum length (ft) of curve C_2 is most nearly:



- ○ A. 60
- ○ B. 90
- ○ C. 120
- ○ D. 180

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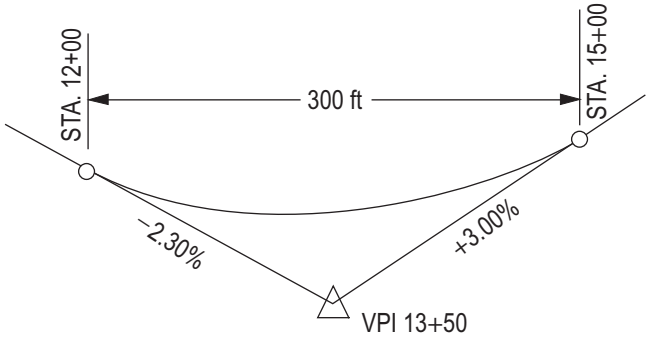
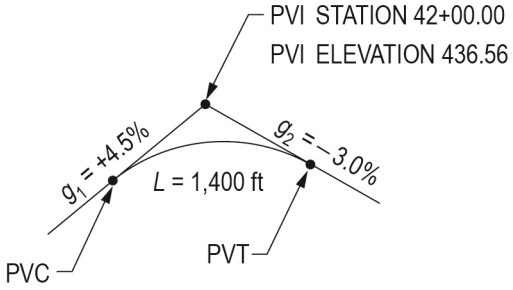
35. For the sag vertical curve shown, the tangent slope at Station 14+00 is most nearly:



NOT TO SCALE

- ○ A. +0.53%
- ○ B. +1.23%
- ○ C. +2.12%
- ○ D. +2.77%

36. The tangent vertical alignment of a section of proposed highway is shown in the figure. The station of the high point is most nearly:



NOT TO SCALE

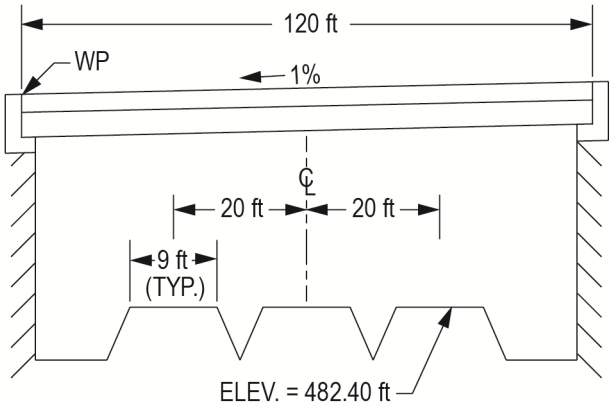
- ○ A. 35+00
- ○ B. 42+00
- ○ C. 43+40
- ○ D. 45+15

PE CIVIL: TRANSPORTATION PRACTICE EXAM

37. An overhead sign is located at the PVI station of a crest vertical curve. The grades are +3% and –2% with a vertical curve length of 500 ft. The PVI of the curve is at Station 85+00 with an elevation of 202.30. In order to provide a clearance of 16 ft, the minimum elevation of the bottom of the sign is most nearly:

- ○ A. 214.14
- ○ B. 215.18
- ○ C. 217.68
- ○ D. 218.30

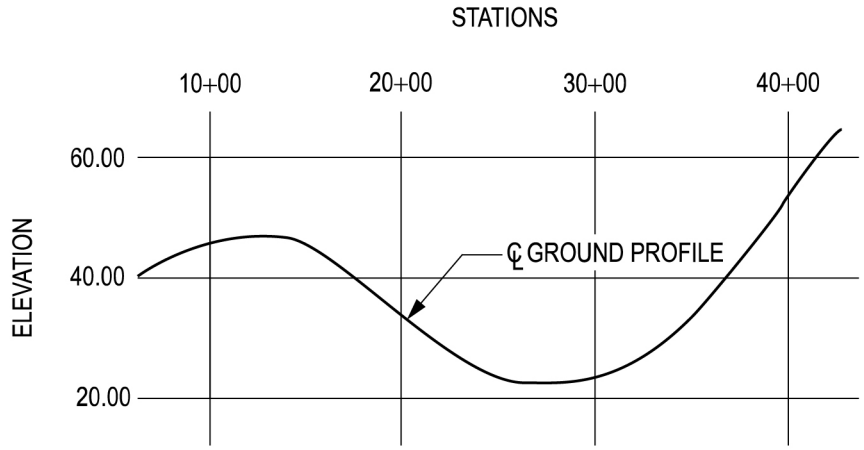
38. The bridge shown is centered over the center railroad. The bridge girders are 60 in. tall and the bridge deck is 6 in. thick. The railroads have the same elevation. If the required clearance over a railroad is 23 ft, the minimum working point (WP) elevation (ft) of the left abutment is most nearly:



- ○ A. 510.30
- ○ B. 510.55
- ○ C. 510.90
- ○ D. 511.26

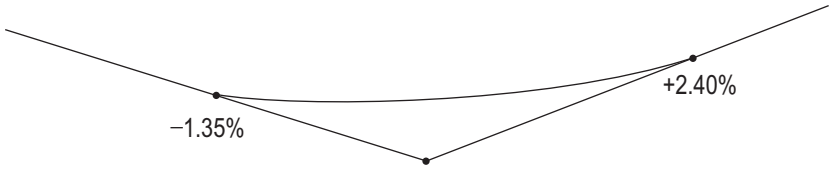
PE CIVIL: TRANSPORTATION PRACTICE EXAM

39. The figure shows a centerline ground profile from Station 10+00 to Station 40+00. The preferred vertical alignment that would closely follow the existing ground profile through this section from Station 20+00 to Station 40+00 would be a:



- ○ A. spiral curve
- ○ B. crest vertical curve
- ○ C. sag vertical curve
- ○ D. compound curve

40. If the vertical curve shown has a design speed of 60 mph, the minimum length of curve (ft) required to provide adequate stopping sight distance is most nearly:



- ○ A. 150
- ○ B. 420
- ○ C. 510
- ○ D. 570

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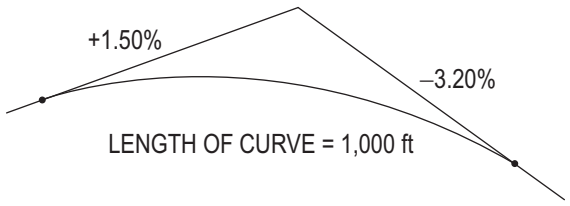
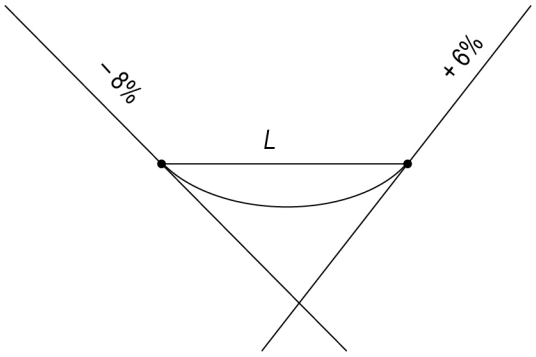
41. According to AASHTO, the passing sight distance (ft) for the vertical curve shown is most nearly:



- ○ A. 1,285
- ○ B. 1,130
- ○ C. 780
- ○ D. 680

42. A roadway stream crossing with fixed street lighting is designed with a sag vertical curve with the intent to limit roadway fill. The minimum length L (ft) of the vertical curve for a 35-mph design speed is most nearly:



- ○ A. 105
- ○ B. 369
- ○ C. 408
- ○ D. 686

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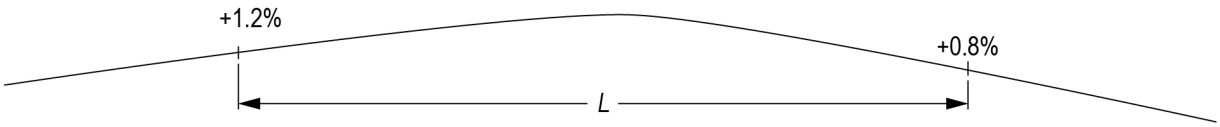
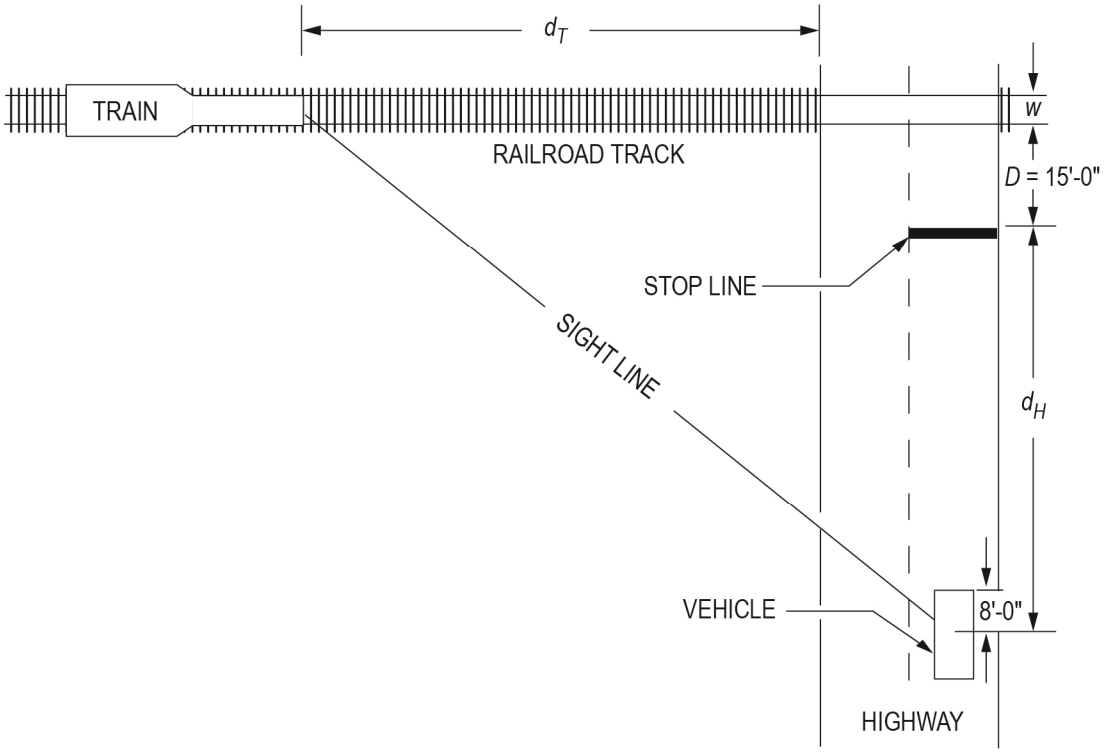
43. A crest vertical curve originally designed to provide passing sight distance is experiencing drainage issues due to the high K value of the curve. If the two-lane, 50-mph design speed roadway is modified to provide only stopping sight distance, the decrease length L (ft) of the curve is _____.

Enter your response in the blank.



44. A vehicle is approaching a train intersection at 45 mph as shown in the figure. Assume AASHTO-recommended design values for perception-reaction time. The stop line is located 15 ft from the nearside rail, and the driver is located 8 ft back from the front bumper of the vehicle. The required sight triangle distance (ft) along the highway for a vehicle to stop at the stop line for an approaching train is most nearly:



- ○ A. 295
- ○ B. 347
- ○ C. 383
- ○ D. 438

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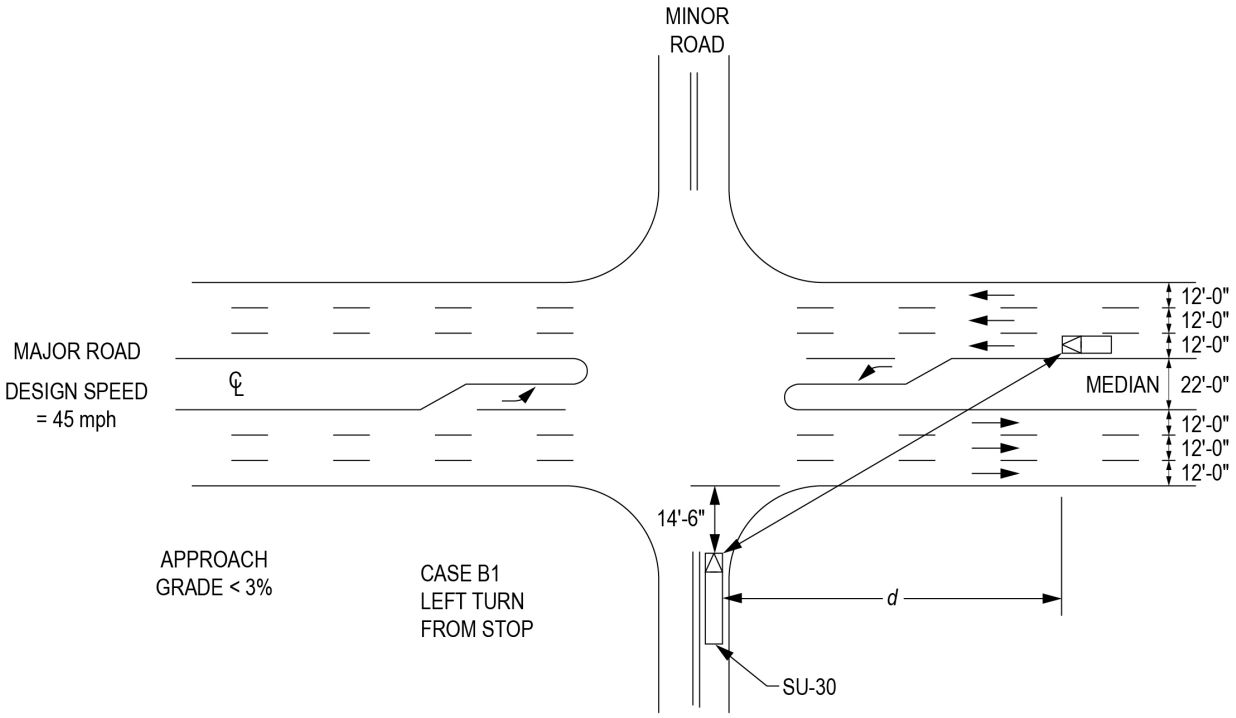
45. The figure shows a single-unit truck on the minor road, which is stop-sign controlled. The truck is making a left turn onto the major road. The dimensions of the travel lanes, the median width, and the position of the single-unit truck are shown. The **minimum** value (ft) of *d* to provide adequate intersection sight distance is most nearly:



- ○ A. 721
- ○ B. 767
- ○ C. 804
- ○ D. 945

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46. A freeway ramp has the following characteristics:

Radius on inner edge of pavement is 100 ft.
One-lane, one-way operation with no provision 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

47. A single-lane entrance ramp joins a tangent section of freeway mainline as a parallel-type entrance. The entrance ramp design speed is 30 mph, and the highway design speed is 70 mph. The grade is +1.0%. The **minimum** acceleration length L (ft) needed for the entrance is most nearly:

- ○ A. 110
- ○ B. 520
- ○ C. 1,230
- ○ D. 1,350

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48. The length (ft) of the acceleration lane for an entrance ramp onto a highway with a 4% upgrade is most nearly:

$V_{highway} = 70$ mph

$V_{ramp} = 50$ mph

- ○ A. 350
- ○ B. 580
- ○ C. 815
- ○ D. 1,050

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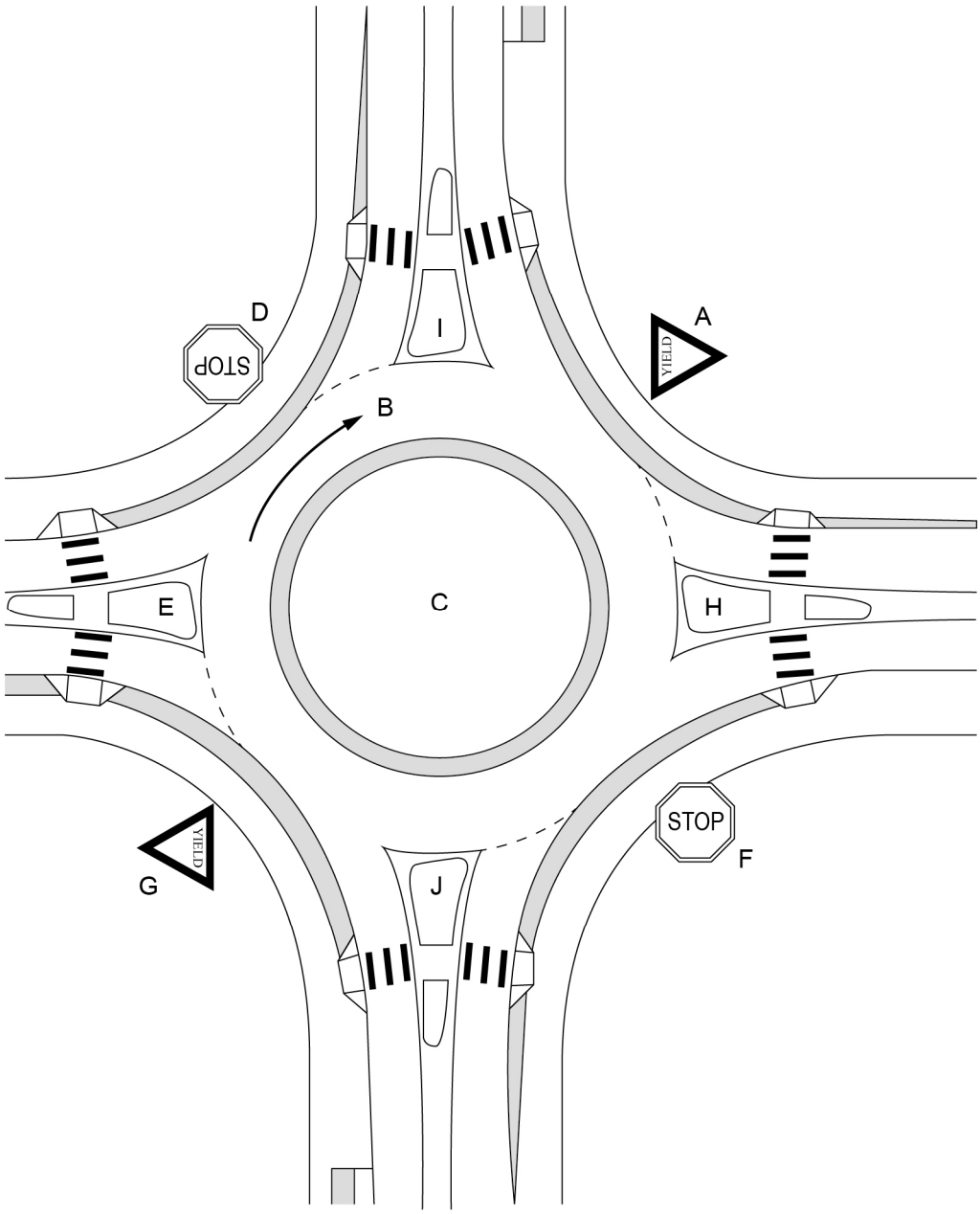
49. Select the characteristics that are typical of modern roundabouts in the United States.



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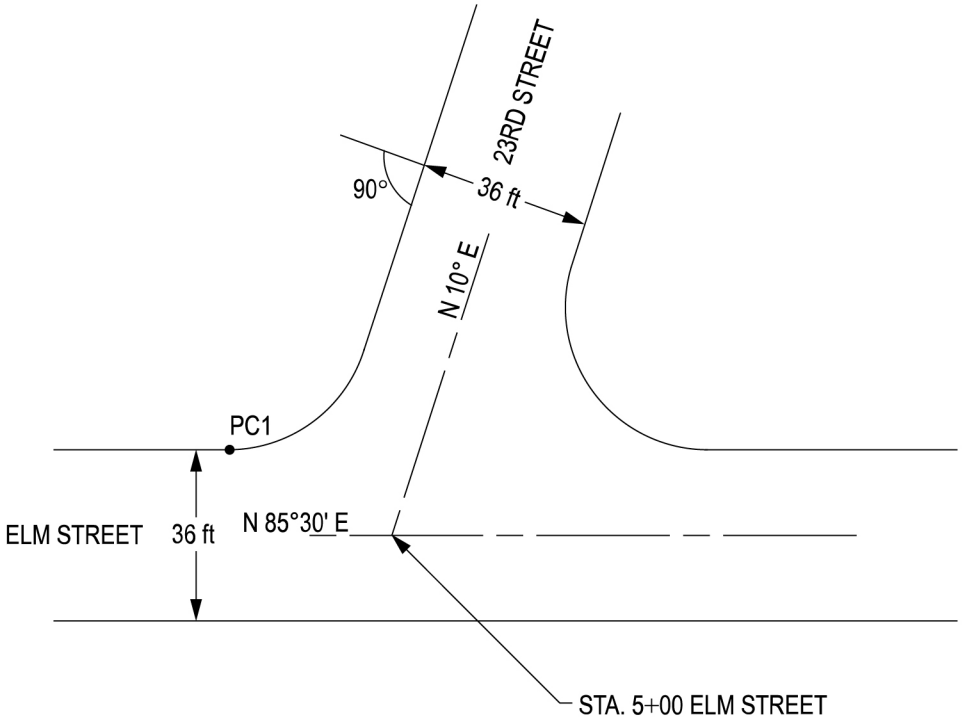
50. The turning radius for both intersection corners shown is 30 ft. Using the centerline of Elm Street, the station of PC1 is most nearly:



- ○ A. 4+76
- ○ B. 4+70
- ○ C. 4+62
- ○ D. 4+52

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51. When an intersection is being designed, which of the following should be considered for the final design?

Select the **five** that apply.

- ☐ A. Distance to next intersection
- ☐ B. Number of truck and bus combinations
- ☐ C. Passing sight distance
- ☐ D. The need for refuge islands
- ☐ E. Adjacent on-street parking
- ☐ F. Sight triangles

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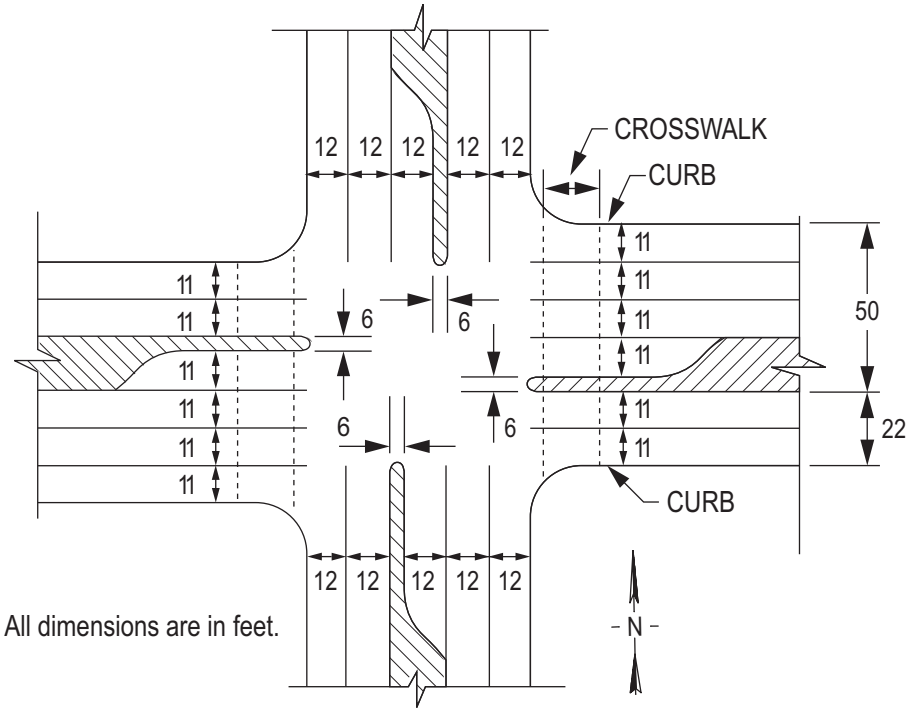
52. The signalized intersection shown has basic pedestrian push buttons. Using curb-to-curb distances, the pedestrian clearance time for the north–south direction per the MUTCD is most nearly:



INTERSECTION PLAN
NOT TO SCALE

- ○ A. 17
- ○ B. 18
- ○ C. 19
- ○ D. 21

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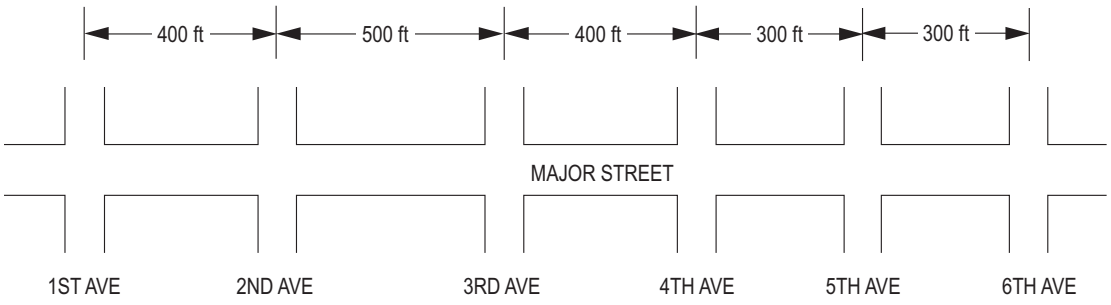
53. A section of a major street—an urban arterial with six traffic signalized intersections—is shown below. The traffic signals at each intersection have a total cycle length of 90 sec with 50 sec of green (and yellow) time on the major street. The design requires a progressive signal system having a maximum bandwidth of green for movement from the 1st Avenue intersection toward the 6th Avenue intersection with a progressive speed of 30 mph. The offset (sec) at 6th Avenue is most nearly:



- ○ A. 36
- ○ B. 43
- ○ C. 50
- ○ D. 63

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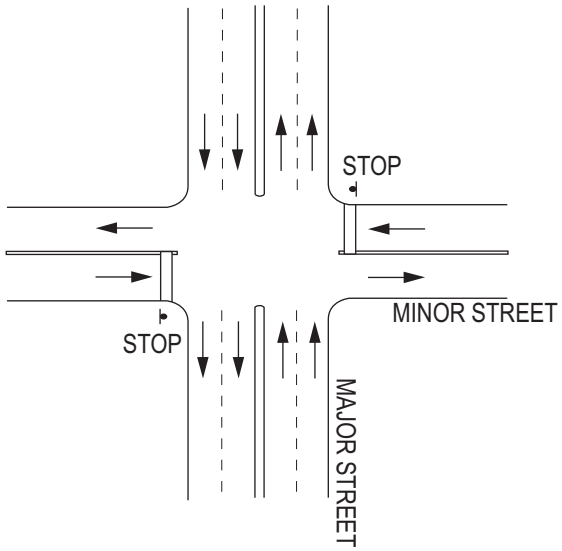
54. The intersection of a major street and a minor street is configured as shown. Traffic counts are shown in the table. The minor street is currently stop-sign controlled. An 8-hour, 4-hour, and crash experience warrant analysis is requested for the intersection. The following data apply:

85th percentile speed: 45 mph
Population: 12,000
9-month crash history:
3 right-angle crashes
2 rear-end crashes
2 left-turning crashes
Alternatives to reduce crash frequency have not resulted in any reductions in the accident rate.

Based on FHWA standards (including optional criteria), which warrants are met?

Hour	Total Vehicles Major Street	Higher-Volume Minor Street Approach (One Direction Only)
6–7 a.m.	735	105
7–8 a.m.	985	120
8–9 a.m.	1,050	135
9–10 a.m.	1,040	104
10–11 a.m.	825	92
11 a.m.–12 p.m.	835	77
12–1 p.m.	847	84
1–2 p.m.	855	111
2–3 p.m.	900	122
3–4 p.m.	1,050	116
4–5 p.m.	1,100	122
5–6 p.m.	1,150	125



- ○ A. Warrant 2
- ○ B. Warrants 1, 7
- ○ C. Warrants 2, 7
- ○ D. Warrants 1, 2, 7

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55. An engineering study will determine if a traffic control signal is justified at a particular location. Which of the following factors does the *Manual on Uniform Traffic Control Devices* include as a recommendation for making this determination?

Select **all** that apply.

- ☐ A. A location with a 50-ft-wide median should be considered as one intersection.
- ☐ B. A traffic control signal should not be installed unless an engineering study indicates that installing a traffic control signal will improve the overall safety and/or operations of the intersection.
- ☐ C. Bicycles should be counted as pedestrians.
- ☐ D. If there are more major-street left turns than side-street volume, the major-street left-turn volume should be considered as the minor-street volume
- ☐ E. A traffic control signal should not be installed if it will seriously disrupt progressive traffic flow.

56. The maximum height (ft) above the pavement to the top of the signal housing of a vehicular signal face located over a roadway is most nearly:

- ○ A. 15
- ○ B. 19
- ○ C. 25
- ○ D. 29

57. In designing a traffic signal, where must the pedestrian signal heads be located?

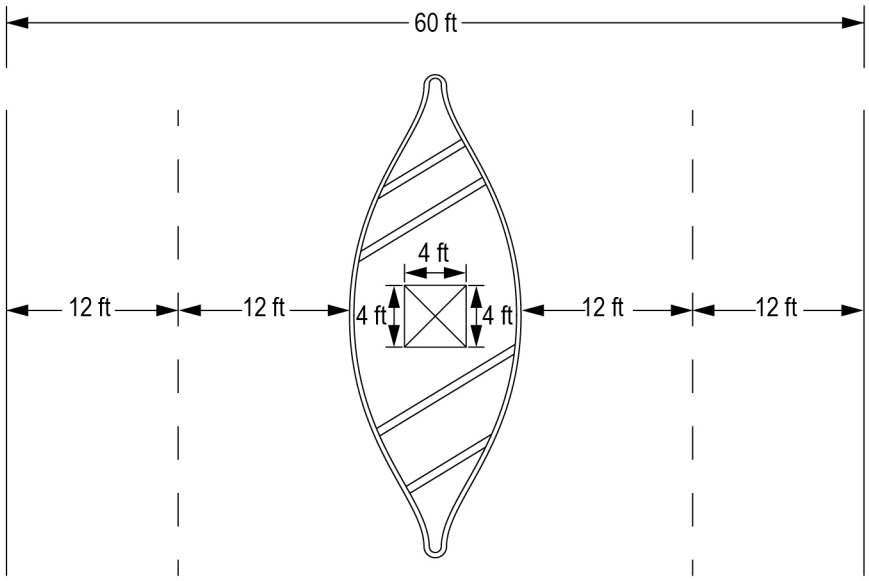
- ○ A. The center of the signal housing must be located 8.5 feet above the sidewalk level.
- ○ B. The top of the signal housing must be located at least 7 feet above the road level.
- ○ C. The bottom of the signal housing must be located 7 to 10 feet above the sidewalk level.
- ○ D. The signal housing must never be on the same support as a vehicular signal head.

PE CIVIL: TRANSPORTATION PRACTICE EXAM

58. Delineators are to be placed on the outside of a horizontal roadway curve of 5°. The approximate spacing (ft) for the delineators along the curve is most nearly:

- ○ A. 50
- ○ B. 90
- ○ C. 95
- ○ D. 100

59. A city plans to place a statue in the middle of a four-lane street in a downtown area with a posted speed limit of 30 mph, as shown in the figure. The minimum length (ft) of taper for the centerline transition is most nearly:



- ○ A. 90
- ○ B. 100
- ○ C. 180
- ○ D. 200

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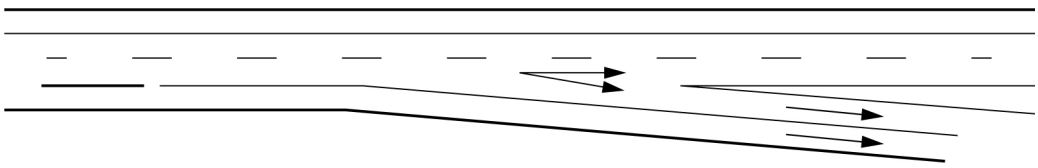
60. Based on MUTCD guidance on freeways, for all multilane exits at major interchanges that have an optional exit lane that also carries the through route, what are the allowable overhead guide signing schemes used for this new reconstruction exit configuration?

Select **all** that apply.



☐ A. Overhead down arrows

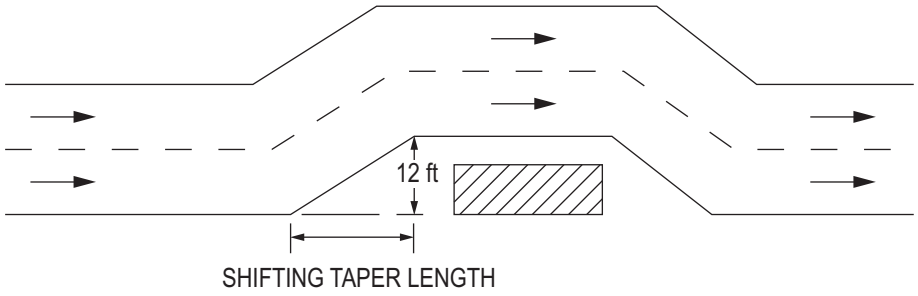
☐ B. Overhead arrow per lane

☐ C. Diagrammatic guide sign with simplified graphics

☐ D. Overhead exit direction sign with ramp advisory speed warning sign

☐ E. Overhead exit direction sign with EXIT ONLY and arrow panels

61. A freeway with a work zone speed limit of 55 mph and 12-ft lanes requires a work zone lane shift as shown. The minimum recommended length (ft) for the shifting taper is most nearly:



○ A. 220

○ B. 305

○ C. 330

○ D. 660

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62. A lane shift will occur within a temporary traffic control zone using reverse curves. The curves will be based on a 25-mph design speed. Which of the following signs should be used to warn motorists of the upcoming lane shift?

- ○ A. W1-2
- ○ B. W1-3
- ○ C. W1-4
- ○ D. W4-2

63. A freeway with two 12-ft-wide lanes in each direction has one lane closed for maintenance. The posted speed is 70 mph. The minimum length (ft) of taper to close the lane is most nearly:

- ○ A. 100
- ○ B. 280
- ○ C. 420
- ○ D. 840

64. Sample concrete cylinders that are 6 inches in diameter and 12 inches high are tested to determine the compressive strength of the concrete f_c'. The test results are as follows:

Sample	Axial Compressive Failure Load (lb)
1	65,447
2	63,617
3	69,872

Based on the test results, the annual average 28-day compressive strength (psi) is most nearly:

- ○ A. 615
- ○ B. 2,250
- ○ C. 2,340
- ○ D. 2,470

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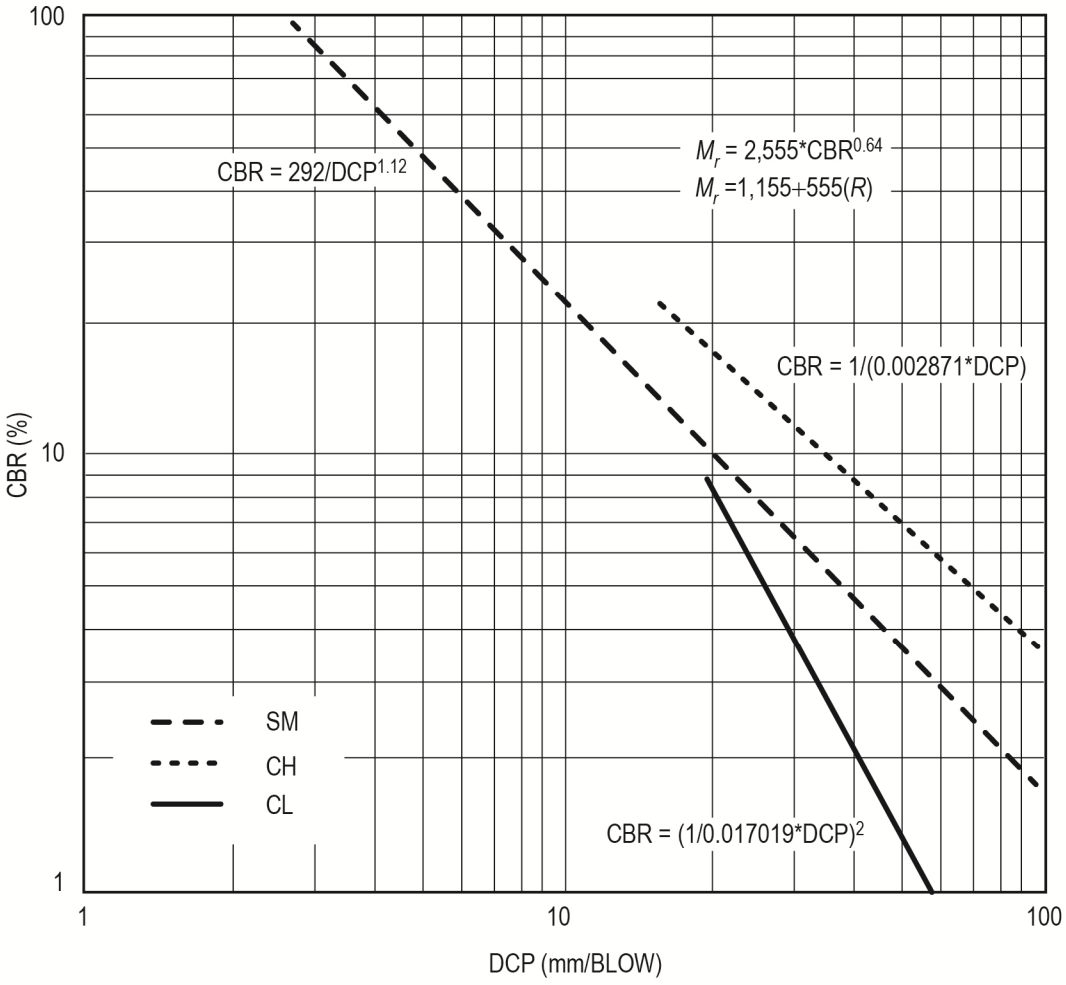
65. The in-place strength of a silty sand subgrade was evaluated using a dynamic cone penetrometer (DCP). The DCP index is 20 mm/blow. Given the relationships shown in the figure, the resistance value (R-value) for the soil is most nearly:



- ○ A. 10
- ○ B. 11
- ○ C. 18
- ○ D. 20

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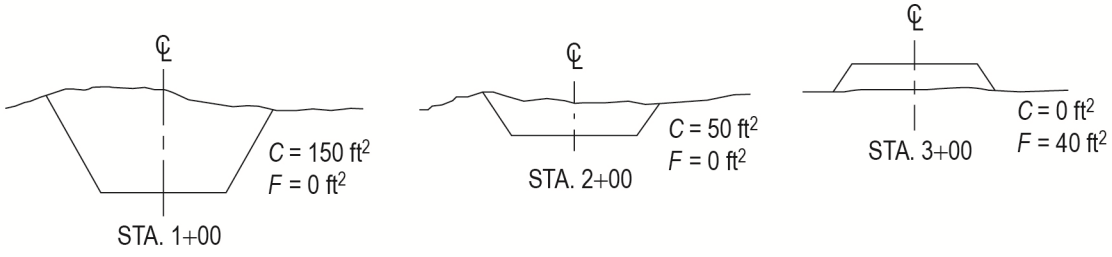
66. The standard penetration test (SPT) is widely used as a simple and economic means of obtaining which of the following?

- ○ A. A measurement of soil compressibility expressed in terms of a compression index
- ○ B. A direct measurement of the undrained shear strength
- ○ C. An indirect indication of the relative density of cohesionless soils
- ○ D. A direct measurement of the angle of internal friction

67. Which of the following soil groupings is **least** likely to present embankment and settlement problems?

- ○ A. Gravels, sands
- ○ B. Gravels, sands, organic silts
- ○ C. Plastic silts, clays
- ○ D. Organic soils, clays

68. Refer to the figure. The net excess excavated material (yd^3) from Station 1+00 to Station 3+00 is most nearly:



- ○ A. 160
- ○ B. 262
- ○ C. 390
- ○ D. 463

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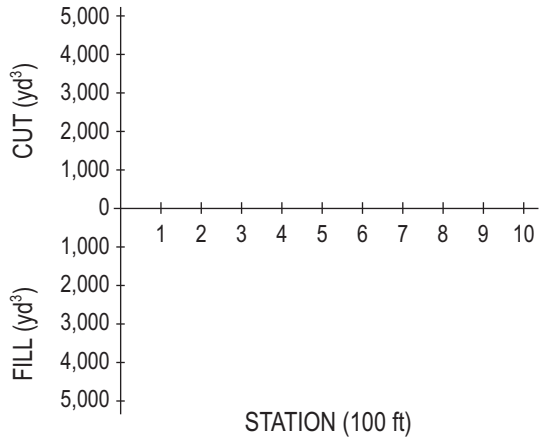
69. Given the earthwork volumes shown in the table, the first balance point on the mass haul diagram is:

Station (ft)	Excavation (yd^3)	Embankment (yd^3)
0+00	0	0
1+00	3,000	1,000
2+00	1,000	500
3+00	1,500	1,000
4+00	2,000	500
5+00	1,000	1,000
6+00	500	2,000
7+00	0	2,000
8+00	0	1,000
9+00	500	1,000
10+00	500	0



- ○ A. Station 5+00
- ○ B. Station 6+00
- ○ C. Station 8+00
- ○ D. Station 10+00

70. Which of the following is **not** a typical contributing factor to the development of alligator cracking?

- ○ A. Lack of adequate support from a shoulder
- ○ B. Weakness of the base course or subgrade
- ○ C. Fatigue failure of the HMA surface from repeated traffic loadings
- ○ D. Insufficient pavement thickness

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71. The following table represents the rainfall recorded from all rain gauges located in and around a drainage area:

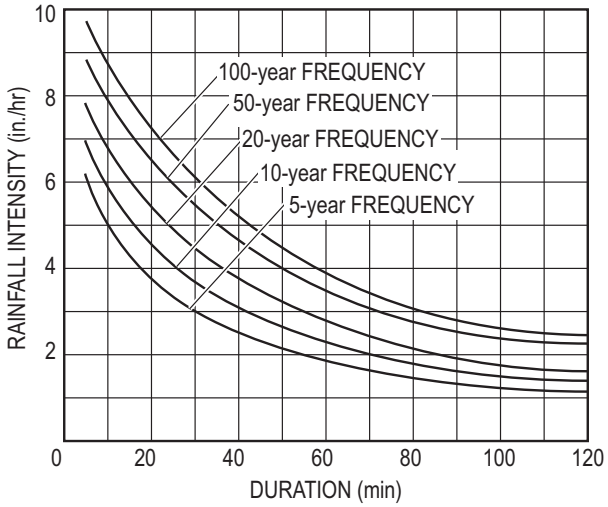
Gauge	A	B	C	D	E	F	G	H	I	J	K
Rainfall (in.)	2.1	3.6	1.3	1.5	2.6	6.1	5.1	4.8	4.1	2.8	3.0

Use the arithmetic mean method. The average precipitation (in.) for the drainage area is most nearly:

- ○ A. 3.4
- ○ B. 3.7
- ○ C. 4.1
- ○ D. 37.0

PE CIVIL: TRANSPORTATION PRACTICE EXAM

72. The rational method must be used to determine the maximum runoff rate for a 90-acre downtown area. The time of concentration for the 50-year frequency storm is 1 hour. Intensity-duration-frequency curves and a table of runoff coefficients are provided. The maximum runoff rate (cfs), based on the maximum runoff coefficient for a 50-year storm, is most nearly:



INTENSITY-DURATION-FREQUENCY CURVES

Description of Area	Runoff Coefficients
Business	
Downtown areas	0.70–0.95
Neighborhood areas	0.50–0.70
Residential	
Single-family areas	0.30–0.50
Multiunits, detached	0.40–0.60
Multiunits, attached	0.60–0.75
Residential (suburban)	0.25–0.40
Apartment dwelling areas	0.50–0.70
Industrial	
Light areas	0.50–0.80
Heavy areas	0.60–0.90
Parks, cemeteries	0.10–0.25
Playgrounds	0.20–0.35
Railroad yard areas	0.20–0.40
Unimproved areas	0.10–0.30
Streets	
Asphalt	0.70–0.95
Concrete	0.80–0.95
Brick	0.70–0.85
Drives and walks	0.75–0.85

- ○ A. 160
- ○ B. 220
- ○ C. 300
- ○ D. 340

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PE CIVIL: TRANSPORTATION PRACTICE EXAM

73. Which of the following is **not** a stormwater erosion classification?

- ○ A. Sheet erosion
- ○ B. Rill erosion
- ○ C. Gully erosion
- ○ D. Rushing erosion

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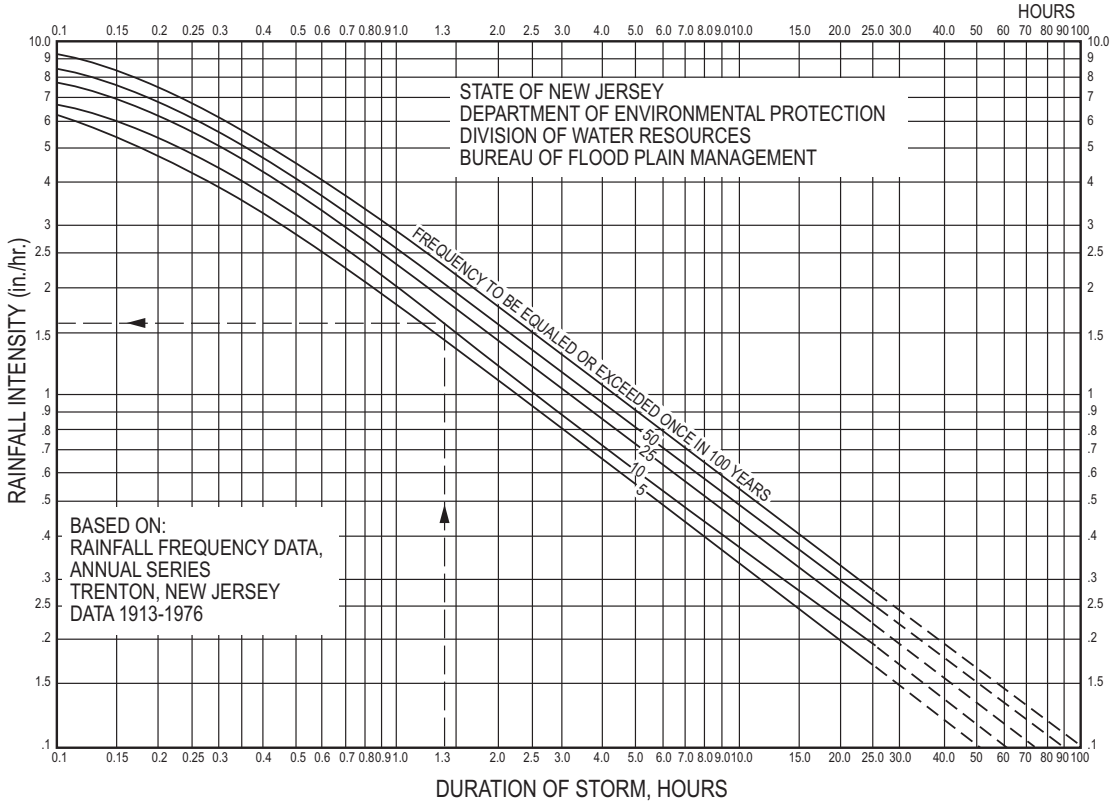
74. An existing watershed has the following characteristics:

Land Use	Area (acres)	*C* Value
Forest	20	0.20
Meadow	10	0.35
Residential	18	0.50
Commercial	2	0.65

The existing average *C* value for the total watershed is 0.36. A 10-acre commercial development has been proposed within the forested land. The existing time of concentration is 0.5 hour. The increase in impervious surfaces from the proposed commercial development will decrease the time of concentration by 30%. Based on the rational formula, the increase in peak runoff (cfs) from the watershed for a 10-year storm due to the commercial development is most nearly:



New Jersey Department of Environmental Protection, Division of Water Resources, Bureau of Flood Plain Management, 1976.

- ○ A. 14
- ○ B. 33
- ○ C. 43
- ○ D. 92

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75. A drainage basin produces a stormwater runoff volume of 25.0 acre-ft, which must be drained through a rectangular channel that is 4 ft wide and 2 ft deep and has a uniform slope of 0.2%. Assume a Manning's roughness coefficient of 0.022 and a constant depth of flow of 1.5 ft. The time (hours) it will take to discharge the runoff is most nearly:

- ○ A. 12.5
- ○ B. 16.4
- ○ C. 18.5
- ○ D. 25.0

76. Two identical 12-in. storm sewers flow full at a 2% slope into a junction box. A single larger pipe of the same material and slope flows out of the box. Assume the pipe sizes are commercially available. The minimum size (in.) of this downstream pipe designed to flow full is most nearly:

- ○ A. 16
- ○ B. 18
- ○ C. 20
- ○ D. 24

77. A stormwater drainage ditch with a maximum capacity of 10 cfs discharges into a detention basin. The detention basin volume is 400,000 gal. During a storm event, the average discharge into the detention basin was 1.5 cfs. The time (hours) to fill the empty basin is most nearly:

- ○ A. 1.5
- ○ B. 9.9
- ○ C. 11.1
- ○ D. 74.1

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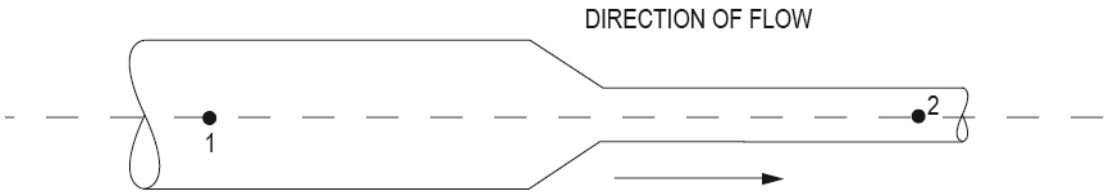
PE CIVIL: TRANSPORTATION PRACTICE EXAM

78. Assume fully turbulent flow in a 1,650-ft section of 3-ft-diameter pipe. The Darcy-Weisbach friction factor f is 0.0115. There is a 5-ft drop in the energy grade line over the section. The flow rate (cfs) is most nearly:

- ○ A. 16
- ○ B. 29
- ○ C. 50
- ○ D. 810

79. Assume that Bernoulli's equation applies (ignore head losses) to the pipe flow shown in the figure. Which of the following statements is most correct?



- ○ A. Pressure head increases from 1 to 2.
- ○ B. Pressure head decreases from 1 to 2.
- ○ C. Pressure head remains unchanged from 1 to 2.
- ○ D. Bernoulli's equation does not include pressure head.

NEXT→

PE CIVIL: TRANSPORTATION PRACTICE EXAM

80. A new rectangular open channel needs to convey 1,800 cfs without exceeding a depth of 4 ft. To ease construction, an even-numbered width is desired. Assume $n = 0.012$ and slope = 6%. The minimum channel width (ft) is most nearly:

- ○ A. 6
- ○ B. 10
- ○ C. 12
- ○ D. 16

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1. Horizontal length of side slope $= 14 \times \frac{3}{2} = 21.0$ ft

Slope length $= \sqrt{(14)^2 + (21)^2} = 25.24$ ft

Cross-sectional area of lining $= \left[(2 \times 25.24) + 9\right]\frac{7}{12} = 34.70 \text{ ft}^2$

Volume of lining $= \frac{(34.70 \times 227)}{27} = 291.7 \text{ yd}^3$

Delivered volume $= 291.7 \text{ yd}^3 \times \underset{\text{(waste)}}{1.12} = 327 \text{ yd}^3$

THE CORRECT ANSWER IS: D

2. Crew cost = 2($50/hr) = $100/hr

Days allowed $= \frac{\$4{,}000}{(8 \text{ hr/day})(\$100/\text{hr})} = 5$ days

THE CORRECT ANSWER IS: C

3. $1{,}000 \text{ kN} = 1{,}000 \text{ kN} \times \frac{1 \text{ ton}}{8.896444 \text{ kN}} = 112.4$ tons

150 tons > 112.4 tons

THE CORRECT ANSWER IS: C

4. Activities: (7) + (4) + (5)

Days: 30 + 10 + 10 = 50 days

THE CORRECT ANSWER IS: D

5. Use the compound interest formula (F/P, i%, n).
$350{,}000\ (1 + 0.035)^{17} = \$628{,}136.44$

THE CORRECT ANSWER IS: 628,000 to 628,200

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6. Calculate annual depreciation:

$$D = \frac{\$75,000 - \$10,000}{10}$$

$$D = \$6,500/\text{year}$$

Book value after 8 years $= \$75,000 - (8)(\$6,500) = \$23,000$

THE CORRECT ANSWER IS: C

7. Determine the annual debt service:

$$R = P\frac{i}{1-(1+i)^{-n}}$$

where

R = annual payment
P = present worth of investment
i = interest rate
n = number of interest periods

$$R = (\$6,987,500)\left(\frac{0.04}{1-(1+0.04)^{-25}}\right)$$

$$= \$447,283.59$$

Alternatively, from economic factor tables available in various references, capital recovery factor (CRF) = 0.06401

$$A = P(A/P, 4\%, 25)$$
$$= (\$6,987,500)(0.0640)$$
$$= \$447,271.56$$

THE CORRECT ANSWER IS: D

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8. Reference: Transportation Research Board, *Highway Capacity Manual*, 6th ed., 2016, pp. 12-19 to 12-39.

Compute the free-flow speed (FFS):

$FFS = BFFS - f_{LW} - f_{RLC} - 3.22 \times TRD^{0.84}$

where:

$BFFS = 60$ mph (given)

$f_{LW} = 0$ (12-ft lanes)

$f_{RLC} = 0$ (10-ft shoulders)

$$TRD = \frac{6 \text{ ramps}}{6 \text{ miles}} = 1 \text{ ramp/mile}$$

$FFS = 60 - 0 - 0 - 3.22\ (1)^{0.84} = 56.8$ mph

Compute f_{HV}, p. 12-35, level terrain $E_T = 2.0$:

$$f_{HV} = \frac{1}{1 + P_T(E_T - 1)} = \frac{1}{1 + 0.05\ (2.0 - 1)} = 0.95$$

Computer flow rate:

$$v_p = \frac{V}{(PHF)(N)(f_{HV})} = \frac{2{,}400}{(0.9)(2)(0.95)} = 1{,}404 \text{ pcphpl}$$

Compute density:

$$\text{Density} = \frac{\text{volume}}{\text{speed}} = \frac{v_p}{S}$$

$S = FFS_{adj}$ if $v_p \le BP$

$FFS_{adj} = FFS \times SAF$, assume $SAF = 1.0$

So $FFS_{adj} = 56.8$ mph

$BP = [1{,}000 + 40\ (75 - FFS_{adj})] \times CAF^2$

$BP = [1{,}000 + 40\ (75 - 56.8)] \times 1.0^2 = 1{,}728$

$1{,}728 > 1{,}404 \quad \therefore \quad S = 56.8$ mph

$$\text{Density} = \frac{1{,}404 \text{ pcphpl}}{56.8 \text{ mph}} = 24.7 \text{ pcpmpl}$$

Find LOS: From p. 12-19, LOS = C

THE CORRECT ANSWER IS: C

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9. Reference: Transportation Research Board, *Highway Capacity Manual*, 6th ed., 2016, pp. 13-21 to 13-29.

Total volume = 4,200 + 500 + 600 + 400 = 5,700
Speed given = 56 mph
Number of lanes, $N = 4$
See p. 13-29, Eqn. 13-23

Since the weaving segment is very long, assume the middle acts like a basic freeway segment (p. 13-21).

$$D = \frac{\left(\frac{V}{N}\right)}{S} = \frac{\left(\frac{5,700}{4}\right)}{56} = \frac{1,425}{56} = 25.44 \text{ pc/mile/lane}$$

THE CORRECT ANSWER IS: A

10. Reference: Transportation Research Board, *Highway Capacity Manual*, 6th ed., 2016, pp. 19-44 to 19-49.

Left turns with protected phasing (exclusive or shared lanes) decrease saturation flow rate.

THE CORRECT ANSWER IS: D

11. Reference: Transportation Research Board, *Highway Capacity Manual*, 6th ed., 2016, pp. 4-16, 19-13, and 19-50.

Saturation flow rate, $s = \frac{3,600 \text{ sec/hr}}{2.4 \text{ sec/veh}}$ Eqn. 4-8

$g = D_p - l_1 - l_2$ Eqn. 19-3

Capacity, $c = Ns\frac{g}{C}$ Eqn. 19-16

$$c = (1)(3,600/2.4)\left(\frac{27 + 3 - 2 - 1}{90}\right) = 450 \text{ vph}$$

THE CORRECT ANSWER IS: D

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12. Reference: FHWA, *Manual on Uniform Traffic Control Devices*, 2009, Section 2B.13.

THE CORRECT ANSWERS ARE: B, D

13. Given:

Vehicles on Street A on Wednesday	10,300
Vehicles on Street B on Wednesday	7,450

Calculate the ratio of vehicles on Street B on Wednesday to the vehicles on Street A on Wednesday:

$$\frac{7,450}{10,300} = 0.7233$$

Calculate the average daily traffic volume for Street B:

$$\text{ADT} = 0.7233 \times \left(\frac{6,950 + 9,450 + 7,340 + 10,300 + 9,850 + 11,250 + 8,450}{7} \right) = 6,570$$

THE CORRECT ANSWER IS: A

14. Total trips = trips per household × total households

$= (0.58 + 1.5\,\text{P} + 2.2\text{A}) \times 600$

$= [0.58 + 1.5\,(4.1) + 2.2(2.3)] \times 600$

$= 11.79 \times 600$

$= 7,074$

THE CORRECT ANSWER IS: 7,050 to 7,100

15. Total vehicles entering intersection = 2,000 + 6,000 + 4,000 + 8,000 = 20,000 vpd.

$$\text{Rate} = \frac{(\text{number of accidents})(10^6)}{(\text{ADT})(\text{number of years})(365 \text{ days/year})}$$

$$= \frac{(25)(10^6)}{(20{,}000)(9/12)(365)} = 4.6 \text{ RMEV}$$

or

$$\text{Rate} = \frac{(\text{number of accidents})(10^6)}{(\text{ADT})(\text{number of days})}$$

Number of days during Jan. through Sept. = 31 + 28 + 31 + 30 + 31 + 30 + 31 + 31 + 30 = 273

$$\text{Rate} = \frac{(25)(10^6)}{(20{,}000)(273)} = 4.6 \text{ RMEV}$$

THE CORRECT ANSWER IS: A

PE CIVIL: TRANSPORTATION SOLUTIONS

16. Reference: Transportation Research Board, *Highway Capacity Manual*, 6th ed., 2016, pp. 24-4 and 24-10 to 24-13.

$$v_p = \frac{v_{15}}{15 \times W_E}$$

where

v_p = pedestrian unit flow rate (p/ft/min)

v_{15} = peak 15-min flow (p)

W_E = effective walkway width (ft)

$$v_p = \frac{1,200}{15(6.5)} = \frac{1,200}{97.5} = 12.3$$

$$A_p = \frac{S_p}{v_p}$$

where

A_p = pedestrian space (ft^2/p)

S_p = pedestrian speed (ft/min)

v_p = pedestrian flow per unit width (p/ft/min)

$$A_p = \frac{280}{12.3} = 22.8 \text{ ft}^2/\text{p}$$

Using Exhibit 24-2 and A_p = 22.8, platoon-adjusted LOS = E.

THE CORRECT ANSWER IS: D

17. Given:

ADT = 12,350 vpd

Growth rate = 7%

Determine ADT 10 years in future assuming growth rate continues:

$$\begin{aligned} \text{ADT}_{\text{future}} &= \text{ADT}_{\text{exist}}(1 + 0.07)^{10} \\ &= 12,350(1.967) \\ &= 24,294 \text{ vpd} \end{aligned}$$

THE CORRECT ANSWER IS: D

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18. Reference: AASHTO, *Roadside Design Guide*, 4th ed., 2011, p. 3-3.

DESIGN SPEED (mph)	ADT	SLOPE	WIDTH
30	400	1V:4H foreslope	7
70	13,000	1V:3H backslope	22
50	4,000	1V:8H foreslope	16
60	1,200	1V:4.5H backslope	16
45	7,000	1V:4H foreslope	24
35	1,000	1V:6H foreslope	10

THE CORRECT ANSWERS ARE SHOWN ABOVE.

19. Reference: AASHTO, *Roadside Design Guide,* 4th ed., 2011, p. 10-4, Figure 10-1.

For curbed sections, the recommended offset on the outside of a curve is 6 ft.

THE CORRECT ANSWER IS: C

20. Reference: AASHTO, *Roadside Design Guide*, 4th ed., 2011, p. 8-36.

Conservation of momentum principle, $V_1 = \dfrac{M_v \times V_o}{(M_v + M_1)}$

$M_v = 2{,}000$ lb $\qquad V_o = 45$ mph $\qquad M_1 = 600$ lb

$$V_1 = \frac{2{,}000 \times 45}{2{,}000 + 600} = 34.6 \text{ mph}$$

THE CORRECT ANSWER IS: A

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21. Reference: AASHTO, *Roadside Design Guide,* 4th ed., 2011, Chapter 8.

The turndown style and the flared end terminal are not crashworthy end treatments. The slotted rail terminal, impact attenuator, inertial barrels, and thrie-beam bullnose have all passed relevant crash tests.

THE CORRECT ANSWERS ARE: A, D

22. Reference: AASHTO, *A Policy on Geometric Design of Highways and Streets*, 2018, Section 10.9.6.3.2, p. 10-122.

"Directional ramps with a design speed over 40 mph [60 km/h] should have a paved right shoulder width of 8 to 10 ft [2.4 to 3.0 m] and a paved left shoulder width of 1 to 6 ft [0.3 to 1.8 m]."

THE CORRECT ANSWER IS: D

23.

Elevation top of curb =	100.0
Deduct curb	–0.5
	99.5
Deduct slab	–0.5
	99.0
Deduct rock	–1.0
	98.0

Consider crown: (30/2) ft × 0.02 = 0.3 ft
Add to above to get Point A.
98.0 + 0.3 = 98.3 ft

THE CORRECT ANSWER IS: A

24. Reference: AASHTO, *A Policy on Geometric Design of Highways and Streets*, 2018, p. 4-70.

Paragraph 3 states "maximum curb ramp grade should be 8.33 percent."

THE CORRECT ANSWER IS: A

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PE CIVIL: TRANSPORTATION SOLUTIONS

25. Reference: AASHTO, *A Policy on Geometric Design of Highways and Streets*, 2018, p. 2-51.

Measures with the potential to reduce vehicle–pedestrian crashes and increase pedestrian comfort in the walking environment include:

Option A: Providing curb extensions (bulb-outs) at intersections
Option C: Using accessible pedestrian signals to provide audible and vibrotactile information
Option D: Providing median refuge islands of sufficient width at wide intersections
Option E: Using repetition and redundancy in design and signing

Option B is incorrect. The use of lower walking speeds, not higher walking speeds, should be used in designing safer pedestrian facilities.

THE CORRECT ANSWERS ARE: A, C, D, E

26. $R = 5,729.648/D_C^\circ$

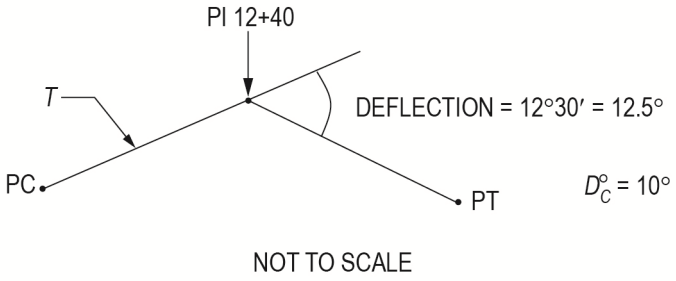
$= 5,729.648/10 = 572.96$ ft

$T = R\tan\left(\frac{1}{2}\Delta\right) = R\tan(6.25°)$

$= 572.96\ (\tan 6.25°)$

$= 572.96\ (0.1095178)$

$= 62.75$ ft



Station PC $=$ Station PI $- T$

$= (12 + 40) - 62.75$

$= 11 + 77.25$

Station PT $=$ Station PC + length of curve

Length of curve $= L = 100\ \Delta/D_C^\circ$

$= 100(12.5)/10 = 125$ ft

Station PT $=$ Station PC $+ 125$ ft $= (11 + 77.25) + 125 = 13 + 02.25$

THE CORRECT ANSWER IS: C

PE CIVIL: TRANSPORTATION SOLUTIONS

27. Determine existing tangent distance:

$$T_{\text{existing}} = R \times \tan\frac{\Delta}{2}$$
$$= 1,200 \times \tan 32.5°$$
$$= 1,200 \times 0.637$$
$$= 764.48 \text{ ft}$$

Determine new tangent:

$$T_{\text{new}} = 764.48 - 200 = 564.48 \text{ ft}$$

Determine new radius:

$$R = \frac{T}{\tan\frac{\Delta}{2}} = \frac{564.48}{0.637}$$
$$= 886.06 \text{ ft}$$

THE CORRECT ANSWER IS: C

28. Distance traveled, $D = vt$
where v = speed
t = perception-reaction time

Distance traveled by alert driver, D_1:

$$v_1 = \frac{45 \text{ miles}}{\text{hour}} \times \frac{5,280 \text{ ft}}{\text{mile}} \times \frac{\text{hr}}{3,600 \text{ sec}} = 66 \text{ ft/sec}$$

$t_1 = 2.5$ sec
$D_1 = 66$ ft/sec $\times$ 2.5 sec = 165 ft

Distance travelled by impaired driver, D_2:
$v_2 = 55 \times 5{,}280/3{,}600 = 80.67$ ft/sec
$t_2 = 3.5$ sec
$D_2 = 80.67 \times 3.5 = 282.3$ ft

Difference = 282.3 – 165 = 117.3 ft

THE CORRECT ANSWER IS: C

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PE CIVIL: TRANSPORTATION SOLUTIONS

29. Reference: AASHTO, *A Policy on Geometric Design of Highways and Streets*, 2018, pp. 3-5, 3-114, and 3-116.

$$\text{Stopping sight distance, SSD} = 1.47\,Vt + 1.075\frac{V^2}{a}$$

where

t = brake reaction time (2.5 sec)

V = design speed (mph)

a = deceleration rate (ft/sec^2)

$$\text{SSD} = 1.47(45)(2.5) + 1.075\left[\frac{(45)^2}{11.2}\right]$$

$$= 165 + 194 = 359\text{ ft}$$

$$\text{Horizontal sightline offset, HSO} = R\left[1 - \cos\frac{28.65\,S}{R}\right]$$

where

S = SSD = stopping sight distance (ft)

R = radius of curve (ft)

$$\text{HSO} = 800\left[1 - \cos\frac{28.65\,(359)}{800}\right]$$

$$= 800(0.025) = 20.06\text{ ft}$$

Can also be solved graphically using Figure 3-14.

THE CORRECT ANSWER IS: B

30. Reference: AASHTO, *A Policy on Geometric Design of Highways and Streets*, 2018, p. 3-22.

The rate of superelevation is given by the following equation:

$$0.01e + f = V^2/15R$$

where:

e = rate of roadway superelevation (%)

f = side friction factor

V = vehicle speed (mph)

R = radius of curve (ft)

$$0.01e + 0.12 = 60^2/(15)(1{,}091)$$

$$e = 10\%$$

THE CORRECT ANSWER IS: B

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31. Reference: AASHTO, *A Policy on Geometric Design of Highways and Streets*, 2018, Chapter 3.

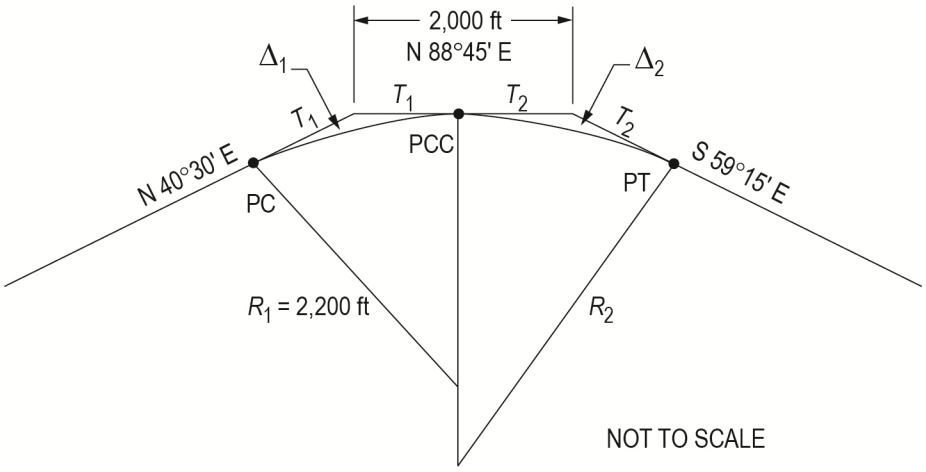
$$L_r = \frac{(2\times 12)\times 4.2}{0.62}(0.75) = 121.94$$ p. 3-66, Table 3-16a

$$L_t = \frac{2}{4.2}\times 121.94 = 58.07$$ p. 3-70, eq. 3-24

Total length = 121.94 + 58.07 = 180 ft

THE CORRECT ANSWER IS: C

32.



$\Delta_1 = 88.75 - 40.5 = 48.25°$

$R_1 = 2,200$ ft

$T_1 = 2,200 \tan\frac{48.25}{2} = 985.26$ ft

$T_2 = 2,000 - 985.26 = 1,014.74$ ft

$\Delta_2 = 1.25 + 30.75 = 32°$

$R_2 = \frac{T_2}{\tan\frac{\Delta_2}{2}} = \frac{1,014.74}{\tan\frac{32}{2}} = 3,538.82$ ft

THE CORRECT ANSWER IS: B

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33. $\Delta = 3°37'28'' = 3.624°$

$$L = \frac{R\Delta\pi}{180} = \frac{10{,}000(3.624°)}{180} = 632.6 \text{ ft}$$

$$[10+50] + (2 \times 632.58) + 30 \text{ ft} + \frac{400}{2} = 25+45.17$$

THE CORRECT ANSWER IS: D

34. Reference: AASHTO, *A Policy on Geometric Design of Highways and Streets*, 2018.

Use recommended 2:1 ratio for compound curve radii from AASHTO paragraph 3.3.7.3 to obtain $R_2 = 400$ ft. Then use Table 3-14 for minimum acceptable curve length to obtain a C_2 length of 120 ft.

THE CORRECT ANSWER IS: C

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35. $L = KA$
$K = L/A$

L = length of vertical curve (ft)

A = algebraic difference in grades, percent $(g_2 - g_1)$

Given: VPC = 12+00
VPI = 13+50
VPT = 15+00
$g_1 = -2.30\%$
$g_2 = +3.00\%$
$L = 300$ ft

$K = \frac{L}{A} = \frac{300}{3-(-2.3)} = 56.60$ ft/percent for the vertical curve.

The length from Station 14+00 to Station 15+00 = 100 ft

$K = \frac{L}{A}$

$A = \frac{L}{K} = \frac{100}{56.60} = 1.77\%$

$A = g_2 - g_1$

Tangent slope at Station 14+00 = g_1

$g_1 = g_2 - A = 3.00\% - 1.77\% = 1.23\%$

Alternate solution:

Y = elevation at a point X ft from VPC
Y' = slope at a point X ft from VPC
$X = [14+00] - [12+00] = 200$ ft
g_1 = slope 1 in ft/ft
g_2 = slope 2 in ft/ft
L = length of vertical curve (ft)

$$Y = Y_{VPC} + g_1 X + \left(\frac{g_2 - g_1}{2L}\right) X^2$$

$$Y' = g_1 + \left(\frac{g_2 - g_1}{L}\right) X$$

$$Y' = -0.023 + \left(\frac{0.03 - (-0.023)}{300}\right) 200 = 0.0123 \text{ ft/ft or } 1.23\%$$

THE CORRECT ANSWER IS: B

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36. Compute the rate of change of grade, r.

$$r = (g_2 - g_1) / L = [-3.0\% - (+4.5\%)] / 14 \text{ sta.} = -0.5357\% / \text{sta.}$$

Compute the distance from the PVC to the high point.

$$X_{\text{PVC}} = -g_1 / r = -(+4.5\%) / (-0.5357\% / \text{sta}) = 8.4002 \text{ sta}$$

Compute the PVC station.

PVC = PVI – L/2 = (42+00) – (7+00) = 35+00

Compute the station of the high point.

High point station = PVC + X_{PVC}
= (35+00) + (8+40.02)
= 43+40.02

Alternate Solution:

Define X as the horizontal distance from the PVC to any point on the curve

Elev. at X: $Y_X = Y_{\text{PVC}} + g_1 X + \left(\frac{g_2 - g_1}{2L} \right) X^2$

Slope at X: $Y'_X = g_1 + \left(\frac{g_2 - g_1}{L} \right) X$

At high point, slope = 0; rearrange for X

$$X = \frac{-g_1 L}{g_2 - g_1} = \frac{(-0.045)(1,400)}{(-0.03) - (0.045)} = 840.00 \text{ ft}$$

Compute PVC station: $\text{PVC} = \text{PVI} - \frac{L}{2} = (42+00) - \frac{1,400}{2} = 35+00$

Compute high point station: PVC + X = (35+00) + 840 = 43+40

THE CORRECT ANSWER IS: C

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37. $$E = \frac{AL}{8}$$

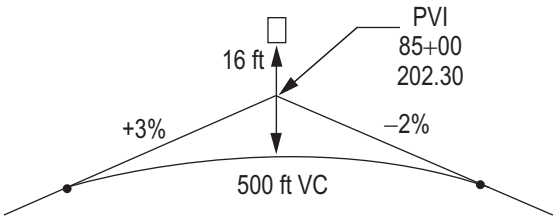
where E = external distance from PVI to the curve

A = algebraic difference of grades, $G_1 - G_2$

L = length of the curve in stations

$$E = \frac{\left(3-\left(-2\right)\right)\left(5\right)}{8} = 3.12$$

Elevation of PVI	202.30
$-E$	-3.12
	199.18
$+16$	$+16$
	215.18



THE CORRECT ANSWER IS: B

38. Elevation at middle of center railroad track:

482.40 ft	
+23.00 ft	clearance
+ 5.00 ft	girder
+ 0.50 ft	deck
510.90 ft	

Minimum clearance is between left edge of left railroad. So, this point is located:

60.00 ft	
−20.00 ft	
− 4.50 ft	
35.50 ft horizontal from abutment	

$\Rightarrow$ Abutment WP elevation = 510.90 ft – 0.01 (35.5 ft)
(Given roadway slope)

= 510.55 ft

THE CORRECT ANSWER IS: B

39. Sag vertical curves are typically used in fill sections, primarily to minimize fill and balance earthwork.

THE CORRECT ANSWER IS: C

40. Reference: AASHTO, *A Policy on Geometric Design of Highways and Streets*, 2018, p. 3-176.

K for 60 mph is 136.
$L = KA$
$L = 136[2.40 - (-1.35)] = 510$ ft

THE CORRECT ANSWER IS: C

41. Reference: AASHTO, *A Policy on Geometric Design of Highways and Streets*, 2018, p. 3-171.

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

$$1,000 = \frac{[1.5 - (-3.2)](S^2)}{2,800}$$

$$2,800,000 = 4.7\,S^2$$

$$S^2 = 595,744$$

$$S = 772 \text{ ft}$$

Verify $S < L \quad \Rightarrow 772 < 1,000 \quad \therefore$ OK

THE CORRECT ANSWER IS: C

42. Reference: AASHTO, *A Policy on Geometric Design of Highways and Streets*, 2018, p. 3-175.

Equation 3-52 provides a minimum length of $L = \dfrac{AV^2}{46.5}$ if the headlight sight distance requirement can be mitigated with street lighting.

THE CORRECT ANSWER IS: B

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43. Reference: AASHTO, *A Policy on Geometric Design of Highways and Streets*, 2018, p. 3-175.

Passing sight distance at 50 mph per Table 3-36 = 800 ft, K value = 229, which exceeds typical drainage maximum of $K = 167$.

$$K = \frac{L}{A} \qquad 229 = \frac{L}{2}$$
$$L_1 = 458\,\text{ft}$$

Stopping sight distance at 50 mph per Table 3-35 = 425 ft, value = 84, which is under the typical drainage maximum of 167.

$$K = \frac{L}{A} \qquad 84 = \frac{L}{2}$$
$$L_2 = 168\,\text{ft}$$

Decrease in vertical curve length is $L_1 - L_2 = 458 - 168$

$L = 290$ ft

THE CORRECT ANSWER IS: 289.5 to 290.5

44. Reference: AASHTO, *A Policy on Geometric Design of Highways and Streets*, 2018, pp. 9-163 and 9-188.

$$d_H = AV_v t + \frac{\left(BV_v^2\right)}{a} + D + d_e$$
$$= (1.47)(45)(2.5) + \left(\frac{1.075(45)^2}{11.2}\right) + 15 + 8$$
$$= 383\,\text{ft}$$

THE CORRECT ANSWER IS: C

45. Reference: AASHTO, *A Policy on Geometric Design of Highways and Streets*, 2018, p. 9-38.

$ISD = 1.47\ (V_{major}) \times (t_g)$
$V_{major} = 45$ mph (given)
$t_g = 9.5$ sec Table 9.5

Since the median is narrower than the length of SU-30, left turn is one step. Add 0.7 sec for each additional lane in excess of one, to be crossed by the turning vehicle.

Crossing distance = (2 lanes) + 22/12 = 3.8 lanes in excess of one.
$t_g = 9.5 + (0.7)(3.8) = 12.16$ sec

$ISD = 1.47\ (45)(12.16) = 804.38$ ft $= d_m$

THE CORRECT ANSWER IS: C

46. Reference: AASHTO, *A Policy on Geometric Design of Highways and Streets*, 2018, pp. 3-109, 3-110, and 10-121.

From Tables 3-27 and 3-28:

Width = 15 ft + 2 ft for vertical curb on both sides
= 17 ft

THE CORRECT ANSWER IS: C

47. Reference: AASHTO, *A Policy on Geometric Design of Highways and Streets*, 2018, p. 10-132.

The acceleration length given in Table 10-4 is 1,350 ft.

THE CORRECT ANSWER IS: D

48. Reference: AASHTO, *A Policy on Geometric Design of Highways and Streets*, 2018, pp. 10-132 and 10-133.

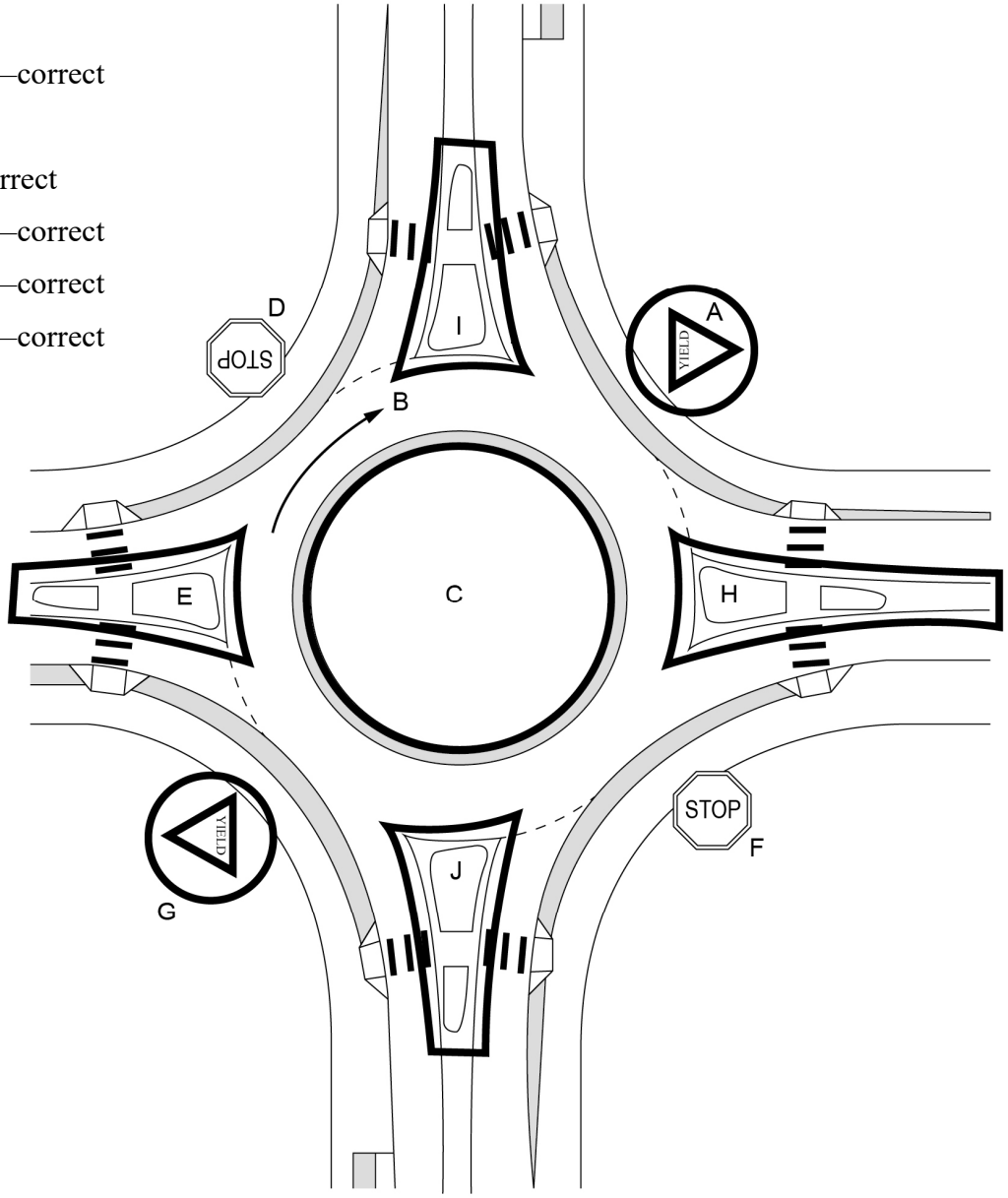
Acceleration length = 580 ft Table 10-4
Grade adjustment factor = 1.8 Table 10-5
$L_{adjusted} = 580 \times 1.8 = 1{,}044$ ft $\Rightarrow 1{,}050$ ft

THE CORRECT ANSWER IS: D

PE CIVIL: TRANSPORTATION SOLUTIONS

49. Reference: AASHTO, *A Policy on Geometric Design of Highways and Streets*, 2018, pp. 9-26 and 9-27.

A. yield sign—correct
B. clockwise circulation
C. central island—correct
D. stop sign
E. splitter island—correct
F. stop sign
G. yield sign—correct
H. splitter island—correct
I. splitter island—correct
J. splitter island—correct



THE CORRECT ANSWERS ARE: A, C, E, G, H, I, J

PE CIVIL: TRANSPORTATION SOLUTIONS

50. PC1 stations along Elm Street

$\Delta_1 = 75°30'$
$R = 30 + 36/2 = 48$ ft
$T_1 = R \tan \Delta_1/2 = 48 \tan (75.5/2) = 37.165$ ft
PI = 5+00
Station of PC1 = (5+00) – (00+37.165) = 4+62.83

THE CORRECT ANSWER IS: C

51. Reference: AASHTO, *A Policy on Geometric Design of Highways and Streets*, 2018, Chapter 9.

The following options are correct and should be considered in the final design:
Option A, distance to next intersection, due to alignment
Option B, number of truck and bus combinations, for radii selection
Option D, refugee islands, depending on the size of radii
Option E, adjacent on-street parking, adjusted due to distance from intersection
Option F, sight triangles, due to signing of the intersection

Option C, passing sight distance, is not a consideration as passing is not typically desirable at an intersection.

THE CORRECT ANSWERS ARE: A, B, D, E, F

52. Reference: FHWA, *Manual on Uniform Traffic Control Devices*, 2009, p. 497.

$$\text{PCT} = \frac{\text{width}}{\text{walking speed}}$$

Walking speed = 3.5 ft/sec
Width (curb to curb) = 11 + 11 + 6 + 11 + 11 + 11 + 11

$$\text{PCT} = \frac{72}{3.5 \text{ ft/sec}} = 20.6 \text{ sec} \approx 21$$

THE CORRECT ANSWER IS: D

53. Offset, $t = \frac{L}{S}$, where $L = \text{block length}\,(\text{ft})$

$S = \text{vehicle speed}\,(\text{fps})$

$L = 400 \text{ ft} + 500 \text{ ft} + 400 \text{ ft} + 300 \text{ ft} + 300 \text{ ft} = 1{,}900 \text{ ft}$

$S = 30 \times 1.47 = 44.1 \text{ fps}$

$t = \frac{1{,}900}{44.1} = 43.08 \text{ sec}$

THE CORRECT ANSWER IS: B

54. Reference: FHWA, *Manual on Uniform Traffic Control Devices*, 2009, Section 4C.

Warrant 1: 8-hour Vehicular Volume
Check Condition A in Table 4C-1.
Since the 85th percentile speed exceeds 40 mph, use the 70% column.
Use the second row of the table for 2 lanes on major street, 1 lane on minor street.
Major street volume meets or exceeds 420 vph all 12 hours (>8).
Minor street volume meets or exceeds 105 vph for 8 of the 12 hours.
Therefore, Warrant 1 is met.

Warrant 2: 4-hour Vehicular Volume
Using Figure 4C-2 (above 40 mph on major street), plot the major and minor street volumes. Each of the first 4 hours plot above the 2-lane major and 1-lane minor curve. Therefore, Warrant 2 is met.

Warrant 7: Crash Experience
Condition A is met; alternatives have not reduced crash frequency.
Condition B is met; 5 of the 7 crashes are subject to correction by a signal; 5 in 9 months equals or exceeds 5 in 12 months.
Condition C is met; since speed exceeds 40 mph, use the 56% column and the second row of Table 4C-1; major and minor volumes exceed table values for 8 hours or more. Therefore, Warrant 7 is met.

THE CORRECT ANSWER IS: D

55. Reference: FHWA, *Manual on Uniform Traffic Control Devices*, 2009, Section 4C.01.

All of the options are contained in whole or part in MUTCD Section 4C.01, Studies and Factors for Justifying Traffic Control Signals. Options A, B, and E are modified from the "Guidance" portion of Section 4C.01; "Guidance" is defined as a recommendation. Options C and D are modified from the "Option" portion of Section 4C.01; "Option" is defined as a permissive condition that carries no recommendation or requirement.

THE CORRECT ANSWERS ARE: A, B, E

56. Reference: FHWA, *Manual on Uniform Traffic Control Devices*, 2009, Section 4D.15.

The distance from the top of the signal housing of a vehicular signal face located over a roadway pavement is 25.6 ft.

THE CORRECT ANSWER IS: C

57. Reference: FHWA, *Manual on Uniform Traffic Control Devices*, 2009, Section 4E.05.

Section 4E.05 Location and Height of Pedestrian Signal Heads Standard

Pedestrian signal heads shall be mounted with the bottom of the signal housing including brackets not less than 7 feet or more than 10 feet above sidewalk level, and shall be positioned and adjusted to provide maximum visibility at the beginning of the controlled crosswalk.

If pedestrian signal heads are mounted on the same support as vehicular signal heads, there shall be a physical separation between them.

THE CORRECT ANSWER IS: C

58. Reference: FHWA, *Manual on Uniform Traffic Control Devices*, 2009, Section 3F.04.

Calculate the radius since the degree of curve is given.

$$R = \frac{5,730}{D} = \frac{5,730}{5} = 1,146 \text{ ft}$$

Since the radius is greater than the largest value shown on Table 3F-1, calculate the spacing by the formula given below Table 3F-1.

$$\text{Spacing, } S = 3\sqrt{R - 50} = 3\sqrt{1,146 - 50}$$
$$= 3\sqrt{1,094} = 3(33.08) = 99.24 \text{ ft}$$

THE CORRECT ANSWER IS: D

59. Reference: FHWA, *Manual on Uniform Traffic Control Devices*, 2009, Section 3B-10.

Since speed < 45 mph

$L = WS^2/60$

$L = (6)(30)^2/60 = 90$

But MUTCD states 100 ft minimum for urban area.

THE CORRECT ANSWER IS: B

60. Reference: FHWA, *Manual on Uniform Traffic Control Devices*, 2009, Section 2E.20.

> **Section 2E.20 Signing for Option Lanes at Splits and Multi-Lane Exits**
> On freeways and expressways, either the Overhead Arrow-per-Lane or Diagrammatic guide sign designs as provided in Sections 2E.21 and 2E.22 shall be used for all multi-lane exits at major interchanges.

Figures 2E-3, 2E-4, 2E-5, 2E-6, 2E-8, and 2E-10 in Chapter 2 are all acceptable signing for the configuration shown in the question (major interchanges).

> **Section 2E.20 Signing for Option Lanes at Splits and Multi-Lane Exits**
> Overhead Arrow-per-Lane or Diagrammatic guide signs shall not be used on freeways and expressways for any other types of exits or splits, including single-lane exits and splits that do not have an option lane.

Options A and D are not allowed by MUTCD.

THE CORRECT ANSWERS ARE: B, C, E

61. Reference: FHWA, *Manual on Uniform Traffic Control Devices*, 2009, Figure 6C-2 and Table 6C-4.

A shifting taper is at least 0.5 L. (Table 6C-3)

$L = WS = 12(55) = 660$ ft (Table 6C-4)

Shifting taper = 0.5 L = 330 ft minimum

THE CORRECT ANSWER IS: C

62. Reference: FHWA, *Manual on Uniform Traffic Control Devices*, 2009, Section 6F.48.

According to Section 6F.48, Reverse Curve Signs (W1-4 Series), if the design speed of the curves is 30 mph or less, a Reverse Turn (W1-3) sign should be used.

THE CORRECT ANSWER IS: B

PE CIVIL: TRANSPORTATION SOLUTIONS

63. Reference: FHWA, *Manual on Uniform Traffic Control Devices*, 2009, Table 6H-4.

Merging taper = L
$L = WS$
$= 12(70)$
$= 840$ ft

THE CORRECT ANSWER IS: D

64. Area = $\pi d^2/4 = 28.3$ in^2

Compressive stress = axial load/area

$$\text{Sample 1} \qquad f_c' = \frac{65,447}{28.3} = 2,313 \text{ psi}$$

$$\text{Sample 2} \qquad f_c' = \frac{63,617}{28.3} = 2,248 \text{ psi}$$

$$\text{Sample 3} \qquad f_c' = \frac{69,872}{28.3} = 2,469 \text{ psi}$$

$$\text{Average} = \frac{(2,313 + 2,248 + 2,469)}{3} = 2,343 \text{ psi}$$

THE CORRECT ANSWER IS: C

65. Reference: AASHTO, *Mechanistic-Empirical Pavement Design Guide*, 2015, Table 9-8, p. 100.

$$\text{CBR} = \frac{292}{\text{DCP}^{1.12}} = \frac{292}{20^{1.12}} = 10.2$$

$$M_r = 2,555(\text{CBR})^{0.64} \simeq 11,300 \text{ psi}$$

$$M_r = 1,155 + 555(R)$$

$$11,300 = 1,155 + 555(R) \Rightarrow R = 18.3 \approx 18$$

THE CORRECT ANSWER IS: C

66. The SPT N-value provides an indication of the relative density of cohesionless soils.

THE CORRECT ANSWER IS: C

67. Soils not subject to consolidation include gravel and sands.

THE CORRECT ANSWER IS: A

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PE CIVIL: TRANSPORTATION SOLUTIONS

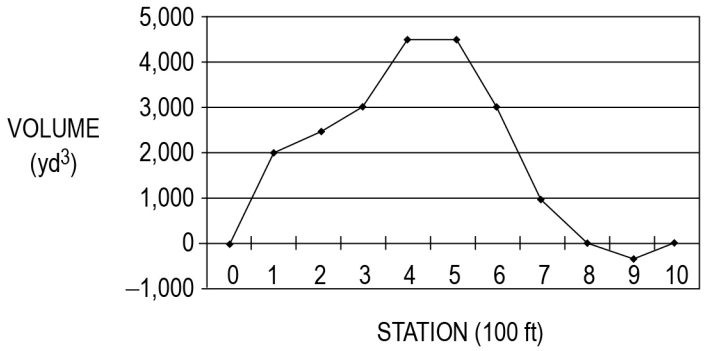
68. Use Average End Area Method.

Stationing	Excavation (yd^3)	Embankment (yd^3)
1+00 to 2+00	$\frac{50+150}{2}\times\frac{100}{27}=370$	
2+00 to 3+00	$\frac{50+0}{2}\times\frac{100}{27}=93$	$\frac{0+40}{2}\times\frac{100}{27}=74$
Total	**463**	**74**

Net excess excavated material = $463-74=389\ yd^3$

THE CORRECT ANSWER IS: C

69.



STATION	EXC.	EMB.	Δ	Σ
0+00	0	0	0	0
1+00	3,000	1,000	2,000	2,000
2+00	1,000	500	500	2,500
3+00	1,500	1,000	500	3,000
4+00	2,000	500	1,500	4,500
5+00	1,000	1,000	0	4,500
6+00	500	2,000	–1,500	3,000
7+00	0	2,000	–2,000	1,000
8+00	**0**	**1,000**	**–1,000**	**0**
9+00	500	1,000	–500	–500
10+00	500	0	500	0

THE CORRECT ANSWER IS: C

70. Lack of shoulder support is a cause of edge cracking.

THE CORRECT ANSWER IS: A

71. According to the arithmetic mean method, the average precipitation is simply the average of all the rainfall gauges.

Average precipitation = (2.1 + 3.6 + 1.3 + 1.5 + 2.6 + 6.1 + 5.1 + 4.8 + 4.1 + 2.8 + 3.0)/11
= 3.4 in.

THE CORRECT ANSWER IS: A

PE CIVIL: TRANSPORTATION SOLUTIONS

72. From the IDF curve, read a rainfall intensity of 3.5 in./hr for a 50-year frequency rainfall with a 60-min duration.

From the table, the runoff coefficient for a downtown area is 0.70–0.95. For the maximum runoff rate, use the high value of 0.95.

$Q = CiA = 0.95 \times 3.5 \text{ in./hr} \times 90 \text{ ac}$

$Q = 300 \text{ cfs}$

THE CORRECT ANSWER IS: C

73. Rushing erosion is not a stormwater erosion classification.

THE CORRECT ANSWER IS: D

74. Existing $t_c = 0.5 \text{ hr } (t_i)$
10-yr storm
From chart, $I_1 = 3.25 \text{ in/hr}$
Average $C = 0.36$ (given)

$$Q_{\text{exist}} = C_1 I_1 A = (0.36)(3.25)(50) = 58.5 \text{ cfs}$$

Calculate C for proposed development:

$$= \frac{(10 \times 0.2) + (10 \times 0.35) + (18 \times 0.5) + (12 \times 0.65)}{50}$$

$$= \frac{2 + 3.5 + 9 + 7.8}{50}$$

$$C_2 = 0.446$$

Calculate new time of concentration:

$$t_2 = t_1 \times 0.7$$
$$= 0.5 \times 0.7$$
$$= 0.35 \text{ hr}$$

From chart for $t_2 = 0.35$ hr and 10-yr storm:

$$I_2 = 4.1 \text{ in./hr}$$
$$Q_{\text{proposed}} = C_2 I_2 A$$
$$= (0.446)(4.1)(50) = 91.4$$

Increase $= 91.4 - 58.5 = 32.9$ cfs

THE CORRECT ANSWER IS: B

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PE CIVIL: TRANSPORTATION SOLUTIONS

75. $$Q = VA = \left\{\frac{1.49}{n} R^{2/3} S^{1/2}\right\} A$$

$$= \left\{\frac{1.49}{0.022}\left[\frac{(1.5\text{ ft} \times 4\text{ ft})}{4\text{ ft} + 2(1.5\text{ ft})}\right]^{2/3} (0.002)^{1/2}\right\}(1.5\text{ ft} \times 4\text{ ft})$$

$$= 16.4\text{ cfs}$$

$$\text{Volume} = 25\text{ acre-ft} \times \frac{43{,}560\text{ ft}^3}{1\text{ acre-ft}} = 1.089 \times 10^6\text{ ft}^3$$

$$\text{Time} = \frac{1.089 \times 10^6\text{ ft}^3}{16.4\text{ ft}^3/\text{sec}} \times \frac{1\text{ min}}{60\text{ sec}} \times \frac{1\text{ hr}}{60\text{ min}}$$

$$= 18.5\text{ hours}$$

THE CORRECT ANSWER IS: C

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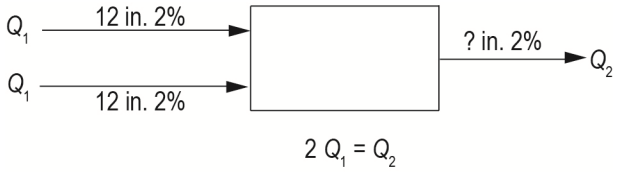
PE CIVIL: TRANSPORTATION SOLUTIONS

76.



$$2[V_1 A_1] = [V_2 A_2]$$

$$2\left[\left(\frac{1.49}{n}\right)(A_1)\, R_1^{2/3}\, S^{1/2}\right] = \left[\left(\frac{1.49}{n}\right)(A_2)\, R_2^{2/3}\, S^{1/2}\right]$$

$$2\left[(A_1)\left(\frac{A_1}{P_1}\right)^{2/3}\right] = \left[(A_2)\left(\frac{A_2}{P_2}\right)^{2/3}\right]$$

$$A_1 = \frac{\pi D^2}{4} = \frac{\pi(1)^2}{4} = 0.785 \text{ ft}^2$$

$$P_1 = \pi(D) = \pi(1) = 3.14 \text{ ft}$$

$$2\left[(0.785)\left(\frac{0.785}{3.14}\right)^{2/3}\right] = \left[\left(\frac{\pi D_2^2}{4}\right)\left(\frac{\frac{\pi(D_2)^2}{4}}{(\pi D_2)}\right)^{2/3}\right]$$

$$0.623 = \left(\frac{\pi D_2^2}{4}\right)\left(\frac{D_2}{4}\right)^{2/3}$$

$$= \pi\left(\frac{D_2^2}{4}\right)\left(\frac{D_2}{4}\right)^{2/3}$$

$$= \pi(D_2)^{8/3}\left(\frac{1}{4}\right)\left(\frac{1}{4}\right)^{2/3}$$

$$0.623 = 0.311(D_2)^{8/3}$$

$$\left(\frac{0.623}{0.311}\right)^{3/8} = D_2$$

$$D_2 = 1.297 \text{ ft} \times \frac{12 \text{ in.}}{\text{ft}} = 15.6 \text{ in.} \approx 16 \text{ in.}$$

THE CORRECT ANSWER IS: A

PE CIVIL: TRANSPORTATION SOLUTIONS

77. $\text{Time} = \dfrac{V}{Q}$

$$V = 400{,}000 \text{ gal} \times \frac{\text{ft}^3}{7.48 \text{ gal}} = 53{,}476 \text{ ft}^3$$

$$Q = 1.5 \text{ ft}^3/\text{sec}$$

$$\text{Time} = \frac{53{,}476 \text{ ft}^3}{1.5 \text{ ft}^3/\text{sec}} \times \frac{1 \text{ hr}}{3{,}600 \text{ sec}} = 9.9 \text{ hours}$$

THE CORRECT ANSWER IS: B

78. The Darcy-Weisbach equation is $h_f = f \dfrac{L}{D} \dfrac{V^2}{2g}$

where

h_f = headloss (ft)
f = friction factor (unitless)
L = length (ft)
D = diameter of pipe (ft)
V = velocity (ft/sec)
g = gravitational constant (32.2 ft/sec^2)

Substituting gives

$$5 \text{ ft} = 0.0115 \times \frac{1{,}650 \text{ ft}}{3.0 \text{ ft}} \times \frac{V^2}{2 \times 32.2 \text{ ft/sec}^2}$$

$$V^2 = 50.91 \text{ ft}^2/\text{sec}^2$$

$$V = 7.135 \text{ ft/sec}$$

$$Q = VA = V \times \frac{\pi}{4} D^2 = 7.135 \text{ ft/sec} \times \frac{\pi}{4} (3.0 \text{ ft})^2$$

$$Q = 50 \text{ cfs}$$

THE CORRECT ANSWER IS: C

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PE CIVIL: TRANSPORTATION SOLUTIONS

79.

$$z_1 + \frac{P_1}{\gamma} + \frac{v_1^2}{2g} = z_2 + \frac{P_2}{\gamma} + \frac{v_2^2}{2g}$$

$z_1 = z_2$

Since $A_1 > A_2$, $v_1 < v_2$.

$\therefore \frac{v_1^2}{2g} < \frac{v_2^2}{2g}$

so $P_1 > P_2$ to balance

THE CORRECT ANSWER IS: B

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PE CIVIL: TRANSPORTATION SOLUTIONS

80. Using Manning's equation:

$$Q = \left(\frac{1.49}{n}\right)(A)(R)^{2/3}(S)^{1/2}$$

$$Q = 1{,}800 \text{ cfs}$$

Given:

maximum depth = 4 ft

slope = 6%

$n = 0.012$

$$1{,}800 = \left(\frac{1.49}{0.012}\right)(A)\left(\frac{A}{P}\right)^{2/3}(0.06)^{1/2}$$

$$(A)\left(\frac{A}{P}\right)^{2/3} = 59.18$$

Trial and error at 4-ft depth:

Width	Area (A)	Wetted Perimeter	$(A)\left(\frac{A}{P}\right)^{2/3}$
6 ft	$4 \times 6 = 24$	$2 \times 4 + 6 = 14$	34.38
8 ft	$4 \times 8 = 32$	$2 \times 4 + 8 = 16$	50.80
10 ft	$4 \times 10 = 40$	$2 \times 4 + 10 = 18$	68.12

$68.12 > 59.18$

$\therefore$ a 10-ft channel width is required

Alternate solution using fewer calculations:

$$A = w \times d$$

$$P = 2d + w$$

$$(w \times d)\left(\frac{w \times d}{2d + w}\right)^{2/3} = 59.182$$

$$(4w)\left(\frac{4w}{8 + w}\right)^{2/3} = 59.182$$

Use the same trial-and-error method as above by substituting w at 6, 8, 10, etc., until greater than 59.182.

THE CORRECT ANSWER IS: B

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