PRACTICE EXAM 11: CALIFORNIA ENGINEERING SURVEYING (100 QUESTIONS)

This practice exam contains 100 multiple-choice questions modeled on the California Civil Engineering Surveying examination content areas. Allow 2.5 hours for a timed simulation. Select the single best answer for each question. Use consistent surveying sign conventions, stationing, and units. An answer key with worked explanations follows the exam.

1. While estimating field effort after a wildfire, a crew traces 5.60 in of access route on an exhibit whose scale converts each inch to 85 ft. Which listed distance belongs in the reconnaissance estimate?

A. 476 ft
B. 425 ft
C. 493 ft
D. 560 ft

2. A reservoir outlet project will excavate around the existing structure for several months. Where should primary control be placed?

A. On paint marks on concrete scheduled for demolition
B. On stable monuments outside the excavation, haul routes, and likely disturbance zone
C. On temporary lath beside the active trench
D. On movable equipment pads near the outlet

3. The acceptance note for a 7,350-ft control loop requires closure no worse than one part in 21,000. Which linear error is the limiting value?

A. 0.21 ft
B. 0.70 ft
C. 2.86 ft

D. 0.35 ft

4. The proportional term in an EDM error budget is 1.5 parts per million. For a 4,800-ft observation, how many feet does that term contribute?

A. 0.00072 ft
B. 0.072 ft
C. 0.0072 ft
D. 0.72 ft

5. A flood-control project must tie proposed grades to a county benchmark network. What should be established before the field crew begins leveling?

A. An arbitrary elevation on the nearest curb
B. The vertical datum, benchmark identity, units, and a reliable project connection to that control
C. A separate local datum for each construction phase
D. A rule that GNSS ellipsoid height will equal project elevation

6. Survey shots will be taken wherever 150-ft orthogonal grid lines intersect across a 900-ft by 600-ft rectangle, and perimeter lines count. How many shot locations are created?

A. 24 points
B. 28 points
C. 42 points
D. 35 points

7. A long urban utility corridor contains several blocks with no direct sight between proposed traverse stations. What is the best reconnaissance response?

A. Add intermediate or offset control so successive observations retain workable intervisibility
B. Increase point descriptions while keeping the blocked geometry

C. Use only one backsight for the entire corridor
D. Ignore the obstruction because coordinates can be entered manually

8. A GNSS control point is proposed immediately beside a chain-link fence topped with metal security panels. What is the principal positioning concern?

A. The fence changes the optical plummet scale factor
B. The fence makes all level rods read too long
C. Nearby reflective surfaces may create multipath and degrade satellite observations
D. Metal panels force the project datum to become assumed

9. Horizontal setup uncertainty has two independent components, 0.018 ft and 0.024 ft. What single resultant uncertainty represents the pair under RSS combination?

A. 0.006 ft
B. 0.030 ft
C. 0.042 ft
D. 0.021 ft

10. A highway reconstruction project contains a station equation. What should the survey control plan require?

A. A new coordinate datum beginning at the equation
B. Independent stationing for each survey crew
C. Removal of all station values before construction staking
D. One documented alignment and stationing convention that identifies the station equation clearly

11. A reconnaissance sheet at 1 inch = 120 ft shows a rectangular staging area measuring 3.25 inches by 2.40 inches. What ground area does the rectangle represent?

A. 93,600 sq ft

B. 134,784 sq ft
C. 112,320 sq ft
D. 78,000 sq ft

12. For a drainage survey at a broad roadside swale, which features should receive deliberate breakline coverage?

A. Swale flow line, tops of bank, pavement edge, culvert inverts, and other grade breaks
B. Only evenly spaced random shots away from the swale
C. Only property monuments regardless of drainage geometry
D. Only photographs because interpolation will define the channel automatically

13. At a 2,200-ft sight length, what angular tolerance in arcseconds produces approximately 0.032 ft of transverse displacement under the small-angle approximation?

A. 1.50 arc-sec
B. 6.00 arc-sec
C. 14.55 arc-sec
D. 3.00 arc-sec

14. A quarry survey needs a dense surface model plus accurate definition of abrupt bench crests and toes. Which planning approach is best?

A. Use only sparse grid shots because contours will create missing breaks
B. Use photographs without measured control
C. Collect dense surface points and supplement them with surveyed breaklines along the bench features
D. Avoid breaklines because dense observations always preserve every discontinuity

15. A robotic total-station project will use mini-prisms, standard prisms, and reflectorless shots. What should the survey plan require?

A. Assume every target has the same zero prism constant

B. Document the target types, prism constants, target heights, and reflectorless procedures before production

C. Use the rod height as the prism constant

D. Change constants only when an angle check fails

16. Static GNSS, network RTK, and total-station observations must ultimately occupy one project coordinate frame. Which planned field relationship makes that integration defensible?

A. Shared control points observable by every measurement method

B. Independent local origins for each instrument type

C. Visual CAD matching after fieldwork

D. Unrelated rotations that are reconciled during construction

17. The preliminary earthwork estimate identifies 2,178,000 square feet of borrow limits. Convert that footprint to acres.

A. 45.0 acres

B. 50.0 acres

C. 55.0 acres

D. 500.0 acres

18. Which network-design choice gives the office meaningful closure and residual checks for detecting a bad control observation?

A. Redundancy guarantees every observation will be identical

B. Redundancy removes the need to document control descriptions

C. Redundancy creates closures and alternate checks that can expose blunders or weak observations

D. Redundancy allows any datum to be substituted without transformation

19. A monitoring alignment places a mark at chainage zero and then every 325 ft through chainage 2,600. Counting the starting mark, how many marks are installed?

A. 8 marks
B. 10 marks
C. 12 marks
D. 9 marks

20. An isolated grading project will use an assumed horizontal coordinate system. What information should be preserved for future recovery?

A. Origin, orientation, units, control descriptions, and any later transformation to external coordinates
B. Only rounded final northings and eastings
C. A claim that the system is state plane without establishing a tie
D. Only the first instrument setup and backsight angle

21. A proposed lidar flight block is 4,200 ft long by 650 ft wide. Approximately how many acres are within the rectangular footprint?

A. 54.86 acres
B. 70.25 acres
C. 626.70 acres
D. 62.67 acres

22. A roadway widening project will be surveyed during active traffic and later construction. What control strategy best protects continuity of the work?

A. Set durable primary control outside expected disturbance and derive replaceable working points closer to operations
B. Place every control point in the existing shoulder scheduled for removal
C. Use temporary paint as the sole project control
D. Allow each crew to establish unrelated control for its own phase

23. A reconnaissance map shows a 2.75-inch distance at a scale of 1 inch = 200 ft. A proposed alternative adds 18% to that route length. What is the alternative ground length?

A. 550 ft
B. 649 ft
C. 568 ft
D. 667 ft

24. A utility owner supplies GIS linework for an existing water main. How should that information be treated when planning excavation-related surveying?

A. Treat GIS display precision as proof of surveyed pipe location
B. Assume all vertices are construction-grade coordinates
C. Use it as background information and verify critical locations with appropriate field methods
D. Discard all GIS information because it can never assist reconnaissance

25. A square equipment yard is shown as 4.10 inches on each side at 1 inch = 70 ft. What is the approximate ground perimeter?

A. 287 ft
B. 820 ft
C. 1,176 ft
D. 1,148 ft

26. Using the HI method, a 5.42-ft backsight is read on BM 412.68. What elevation does the instrument line of sight represent?

A. 407.26 ft
B. 418.10 ft
C. 414.84 ft
D. 423.52 ft

27. The instrument line of sight is elevation 418.10 ft, and the turning point is known to be elevation 411.73 ft. What foresight reading should connect those two elevations?

A. 6.37 ft
B. 5.42 ft
C. 6.73 ft
D. 829.83 ft

28. A total-station setup is established over known control. Before collecting hundreds of detail shots, what is the strongest immediate orientation check?

A. Trust the stored backsight name without another observation
B. Begin detail collection and check only at the end of the day
C. Observe a second known control point and compare the measured or computed check
D. Change the prism height until one point appears to fit

29. A slope distance is 642.80 ft at a zenith angle of 88 degrees 30 minutes. What is the horizontal distance, to the nearest 0.01 ft?

A. 16.83 ft
B. 642.58 ft
C. 642.80 ft
D. 626.00 ft

30. For the same 642.80-ft slope sight at zenith angle 88 degrees 30 minutes, what is the vertical component magnitude?

A. 16.83 ft
B. 642.58 ft
C. 8.42 ft
D. 33.66 ft

31. A total station measures a horizontal angle four times: 73°18′22″, 73°18′26″, 73°18′24″, and 73°18′20″. What is the arithmetic mean?

A. 73°18′22″
B. 73°18′24″
C. 73°18′23″
D. 73°18′26″

32. A steel tape nominally 100.00 ft long is actually 100.03 ft under field conditions. A recorded distance is 760.00 ft. What corrected distance results from tape length only?

A. 759.77 ft
B. 760.03 ft
C. 762.28 ft
D. 760.23 ft

33. A small collimation error is suspected in a level. Which setup geometry most directly helps its effect cancel between two elevation observations?

A. Use a very long backsight and a very short foresight
B. Eliminate all turning points from the run
C. Keep backsight and foresight sight lengths approximately equal
D. Read only the upper stadia hair on each rod

34. BM elevation is 245.66 ft and the backsight is 4.18 ft. To establish an intermediate point at elevation 241.92 ft from that same setup, what rod reading is required?

A. 3.74 ft
B. 7.92 ft
C. 4.18 ft
D. 11.84 ft

35. A prism is set 5.60 ft above point P. The total station instrument height is 5.10 ft, and the measured vertical component from instrument axis to prism is +2.45 ft. If the occupied point elevation is 680.25 ft, what is the elevation of P?

A. 682.20 ft
B. 687.30 ft
C. 676.65 ft
D. 682.70 ft

36. A rod reading on a turning point changes noticeably when the rod is rocked. Which reading should be accepted for a standard level rod held on the same point?

A. The maximum reading because it represents the tallest rod position
B. The average of the first and last readings regardless of rocking
C. Any reading if the rod bubble is not visible
D. The minimum reading observed while the rod is rocked through vertical

37. A distance is measured twice as 528.42 ft and 528.38 ft. What is the percent difference relative to their mean?

A. 0.076%
B. 0.0038%
C. 0.0076%
D. 0.76%

38. A crew begins reflectorless shots on a dark wall after collecting prism observations. What field precaution is most important?

A. Confirm the instrument is in the intended reflectorless mode and check a known distance before production
B. Leave the instrument in prism mode because the wall reflects light
C. Use prism height as the reflectorless target height

D. Assume surface color cannot influence any reflectorless observation

39. A leveling computation closes at 518.602 ft on a benchmark published as 518.630 ft. What correction must be added to the computed closing elevation to agree with the benchmark?

A. -0.028 ft
B. +0.028 ft
C. +0.056 ft
D. +8.357 ft

40. A total station is centered 0.012 ft east and 0.016 ft north of the intended point. What is the magnitude of the centering offset?

A. 0.004 ft
B. 0.028 ft
C. 0.014 ft
D. 0.020 ft

41. A closure plot places the computed endpoint 0.18 ft north and 0.24 ft west of its required position. What straight-line distance separates the two endpoints?

A. 0.06 ft
B. 0.42 ft
C. 0.24 ft
D. 0.30 ft

42. A 6,750-ft traverse closes by 0.27 ft. Which denominator N correctly expresses its closure ratio as approximately 1:N?

A. 1:25,000
B. 1:12,500

C. 1:27,000
D. 1:2,500

43. A 920-ft traverse course has azimuth 32°40′. What is its latitude, with north positive?

A. +496.57 ft
B. -774.48 ft
C. +774.48 ft
D. +920.00 ft

44. A 920-ft line runs at azimuth 32 degrees 40 minutes. What east-west coordinate increment does that course produce?

A. +774.48 ft
B. +496.57 ft
C. -496.57 ft
D. +423.43 ft

45. Which clockwise-from-north azimuth describes a course whose quadrant bearing is S 27 degrees 15 minutes E?

A. 27°15′
B. 207°15′
C. 152°45′
D. 332°45′

46. A direction of 286 degrees 20 minutes is given in azimuth form. Which quadrant-bearing notation represents the same line?

A. N 16°20′ W
B. N 73°40′ E

C. S 16°20′ E
D. N 73°40′ W

47. For a coordinate check, A is at E 2,450.00, N 7,125.00 and B is at E 2,890.00, N 7,455.00. What direct horizontal distance should be observed?

A. 550.00 ft
B. 440.00 ft
C. 330.00 ft
D. 770.00 ft

48. Using the same coordinates, what is the azimuth from A to B?

A. 36.87°
B. 53.13°
C. 126.87°
D. 233.13°

49. A four-sided traverse should total exactly 360 degrees internally, but the observed angles sum to 359 degrees 59 minutes 44 seconds. How much angle must be added to reach the theoretical total?

A. -16 arc-sec
B. +16 arc-sec
C. +44 arc-sec
D. +4 arc-sec

50. Four adjusted directions must absorb a traverse angle deficit of 16 arcseconds equally. What signed correction belongs on each measured angle?

A. -4 arc-sec
B. +8 arc-sec

C. +4 arc-sec
D. +16 arc-sec

51. A Bowditch adjustment weights corrections by course length. A 780-ft course belongs to a traverse totaling 3,900 ft. What percentage of the total latitude correction is assigned to that course?

A. 5%
B. 25%
C. 50%
D. 20%

52. A level run contains 18 instrument setups and has a closing error of +0.036 ft. If correction is distributed equally by setup, what correction is applied to each setup increment?

A. -0.002 ft per setup
B. +0.002 ft per setup
C. -0.036 ft per setup
D. -0.018 ft per setup

53. A sloping observation measures 1,025.00 ft and rises at 6 degrees 20 minutes above horizontal. What plan-horizontal component should be used?

A. 113.11 ft
B. 1,018.74 ft
C. 1,025.00 ft
D. 1,012.50 ft

54. For the same 1,025.00-ft slope distance and +6°20′ vertical angle from horizontal, what is the vertical component?

A. +1,018.74 ft

B. -113.07 ft
C. +113.07 ft
D. +56.54 ft

55. A circular curve has a 41-degree central angle and a PI-to-PC tangent distance of 317.80 ft. What radius corresponds to that geometry?

A. 850 ft
B. 425 ft
C. 608.25 ft
D. 1,271.2 ft

56. The centerline arc turns 41 degrees on an 850-ft radius. How much station length lies along the circular arc?

A. 317.80 ft
B. 595.00 ft
C. 1,216.50 ft
D. 608.25 ft

57. For a curve whose PI is station 38+75.00, the computed tangent distance back to the beginning of curve is 317.80 ft. What station is the PC?

A. 38+75.00
B. 41+92.80
C. 35+57.20
D. 32+39.40

58. If the curve in the previous question has length 608.25 ft, what is the PT station?

A. 41+65.45

B. 38+75.00
C. 41+92.80
D. 44+83.70

59. On a 500-ft crest vertical curve, the incoming grade is +2.4% and the outgoing grade is -1.6%. What instantaneous grade occurs 175 ft beyond the PVC?

A. +0.40%
B. +1.00%
C. +1.40%
D. -1.00%

60. Profile elevation at the PVC is 744.20 ft. Over the next 500 ft the tangent grade changes parabolically from +2.4% to -1.6%. What is the curve elevation at x = 175 ft?

A. 748.40 ft
B. 746.62 ft
C. 750.08 ft
D. 747.18 ft

61. The zero-grade point on a 500-ft crest curve with grades +2.4% and -1.6% occurs 300 ft from the PVC. What percentage of the curve length is that?

A. 40%
B. 50%
C. 60%
D. 75%

62. A site rectangle is 285.6 ft wide and 418.3 ft long. Express its computed area in acres rather than square feet.

A. 2.743 acres
B. 2.437 acres
C. 2.974 acres
D. 27.43 acres

63. An easement forms a triangle with a 240-ft base and a 135-ft altitude normal to that base. What area is enclosed?

A. 32,400 sq ft
B. 18,750 sq ft
C. 8,100 sq ft
D. 16,200 sq ft

64. An excavation template has parallel top and bottom widths of 30 ft and 18 ft. What average width is used before multiplying by the 6-ft depth in the trapezoid area formula?

A. 6 ft
B. 24 ft
C. 12 ft
D. 48 ft

65. Two end areas for an earthwork segment are 144 sq ft and 216 sq ft, separated by 80 ft. Using the average-end-area method, what volume results in cubic yards?

A. 480.00 cu yd
B. 533.33 cu yd
C. 1,066.67 cu yd
D. 180.00 cu yd

66. A baseline point has coordinates E 8,250.00 ft, N 3,900.00 ft. A second point is 360 ft away at azimuth 125°. What are the coordinates of the second point?

A. E 8,456.49 ft, N 4,194.89 ft
B. E 7,955.11 ft, N 3,693.51 ft
C. E 8,544.89 ft, N 4,106.49 ft
D. E 8,544.89 ft, N 3,693.51 ft

67. A point has coordinates E 6,120.00 ft, N 9,400.00 ft. A line of bearing S 35° E extends 425 ft. What is the ending easting?

A. E 6,363.77 ft
B. E 5,876.23 ft
C. E 6,468.13 ft
D. E 6,120.00 ft

68. For the same S 35° E, 425-ft line from N 9,400.00 ft, what is the ending northing?

A. N 9,748.64 ft
B. N 9,156.77 ft
C. N 9,051.86 ft
D. N 9,400.00 ft

69. Why should intermediate calculations retain more digits than the final reported survey value?

A. Extra digits make every measurement more accurate than the instrument
B. Premature rounding can accumulate and shift later coordinates, grades, or closures
C. Final values should always display every calculator digit
D. Rounding is prohibited in all surveying calculations

70. Between station 12+50 and station 16+30, profile elevation increases from 325.40 ft to 331.10 ft with no grade break. What signed percent grade describes the line?

A. +1.50%

B. +1.20%
C. +1.80%
D. -1.50%

71. Between adjacent 612-ft and 614-ft contours, a point falls 25% of the way from the lower contour toward the higher on an assumed uniform slope. What elevation should be assigned?

A. 612.25 ft
B. 613.0 ft
C. 613.5 ft
D. 612.5 ft

72. Two control points are 392 ft apart on the ground and plot 7.84 inches apart. What engineering scale in feet per inch is represented?

A. 1 in = 40 ft
B. 1 in = 60 ft
C. 1 in = 50 ft
D. 1 in = 80 ft

73. Closely spaced contour lines cross a hillside while widely spaced contours occur nearby. What does the close spacing indicate?

A. A flatter slope because elevations change more slowly
B. A steeper ground slope in the closely spaced area
C. A change in horizontal datum
D. A location where contour interval becomes zero

74. A profile stretches horizontal distances using 1 in = 100 ft but plots elevations at 1 in = 20 ft. By what factor are vertical changes exaggerated?

A. 0.2:1
B. 20:1
C. 5:1
D. 100:1

75. A map at 1 inch = 80 ft shows a polygon with plotted area 12.5 square inches. What ground area does that represent?

A. 1,000 sq ft
B. 6,400 sq ft
C. 100,000 sq ft
D. 80,000 sq ft

76. When preparing contours from surveyed surface data, why should a ditch flow line be included as a breakline?

A. It constrains triangulation so the mapped surface preserves the drainage low point
B. It changes the horizontal scale only along the ditch
C. It guarantees all spot elevations are error free
D. It replaces the need for any measured elevations near the ditch

77. A 6-ft contour interval map shows a uniform slope between elevations 420 ft and 450 ft over a horizontal distance of 375 ft. What is the average slope percent?

A. 8.0%
B. 6.0%
C. 12.5%
D. 80.0%

78. A map labels a benchmark as elevation 528.34 ft and also shows an assumed local benchmark at 100.00 ft. What is the most important cartographic requirement?

A. Plot both with the same symbol and omit datum notes

B. Clearly distinguish the two vertical references so users do not combine elevations from different datums

C. Average the benchmark values to create one elevation

D. Delete the lower elevation because smaller numbers are less accurate

79. A plan is printed at 1 inch = 40 ft. A line intended to be 180 ft long plots as 4.40 inches. What plotting discrepancy in ground feet does that represent?

A. 0.4 ft short

B. 4.0 ft long

C. 44.0 ft short

D. 4.0 ft short

80. Why should a finished topographic map avoid displaying coordinate precision far finer than the underlying survey supports?

A. More decimals automatically improve the survey

B. Fine precision changes the coordinate datum

C. Excess digits can imply more positional accuracy than the survey supports

D. Coordinate values are accurate only when rounded to whole feet

81. A storm-drain run advances 350 ft at a 1.20% downgrade. How much vertical drop occurs over that station interval?

A. 1.20 ft

B. 4.20 ft

C. 2.92 ft

D. 42.00 ft

82. A curb profile has no vertical break between station 6+40, elevation 512.30 ft, and station 9+20, elevation 516.50 ft. What uniform percent grade connects them?

A. +1.20%
B. +1.80%
C. -1.50%
D. +1.50%

83. Centerline is 0.28 ft above the pavement edge at a perpendicular offset of 14 ft. What percent cross-slope magnitude does that geometry represent?

A. 2.00%
B. 0.50%
C. 1.40%
D. 4.00%

84. A station equation occurs at a point on a roadway centerline. What must the staking crew remember?

A. The alignment has a physical gap equal to the station jump
B. The horizontal datum changes automatically at the equation
C. The physical alignment is continuous even though the station label changes at that location
D. All offsets reverse direction after the equation

85. A tangent alignment starts at station 20+00 with coordinates E 5,000.00 ft, N 8,000.00 ft and runs due east. What are the coordinates at station 23+65?

A. E 5,365.00 ft, N 8,000.00 ft
B. E 5,000.00 ft, N 8,365.00 ft
C. E 4,635.00 ft, N 8,000.00 ft
D. E 5,365.00 ft, N 8,365.00 ft

86. At station 23+65 an eastbound baseline point is E 5,365.00, N 8,000.00. A required stake is 22 ft to the alignment left. Which coordinates locate it?

A. E 5,365.00 ft, N 7,978.00 ft
B. E 5,387.00 ft, N 8,000.00 ft
C. E 5,365.00 ft, N 8,022.00 ft
D. E 5,343.00 ft, N 8,000.00 ft

87. For layout of a 36-degree circular deflection with 620-ft radius, what PI-to-PC tangent distance is required?

A. 389.56 ft
B. 201.45 ft
C. 191.62 ft
D. 402.90 ft

88. A curve PI is station 52+40.00 and its PC is station 50+38.55. What tangent distance separates the PI from the PC?

A. 188.55 ft
B. 389.56 ft
C. 441.45 ft
D. 201.45 ft

89. A 620-ft-radius horizontal curve subtends 36 degrees. What length of centerline follows the circular arc from PC to PT?

A. 201.46 ft
B. 403.00 ft
C. 389.56 ft
D. 779.12 ft

90. Stationing at the PC is 50+38.55, and 389.56 ft of centerline arc follows. What station should be assigned to the PT?

A. 54+28.11
B. 52+40.00
C. 54+41.46
D. 58+17.66

91. A 360-ft sag curve changes tangent grade uniformly from -2.0% at the PVC to +1.0% at the PVT. What grade is tangent to the curve at x = 120 ft?

A. 0.00%
B. -1.50%
C. +1.00%
D. -1.00%

92. The PVC of a 360-ft sag curve is elevation 680.00 ft. With g1 = -2.0% and g2 = +1.0%, what profile elevation occurs 120 ft from the PVC?

A. 677.60 ft
B. 678.20 ft
C. 678.80 ft
D. 682.20 ft

93. After staking a 72-ft by 96-ft rectangular column bay, what corner-to-corner distance should the crew use as the theoretical diagonal check?

A. 108.00 ft
B. 144.00 ft
C. 120.00 ft
D. 168.00 ft

94. A trench centerline is at elevation 402.15 ft. The pipe invert must be 7.80 ft below that reference elevation. What is the design invert?

A. 409.95 ft
B. 395.35 ft
C. 393.15 ft
D. 394.35 ft

95. A sidewalk has design elevation 225.60 ft at one end and 224.20 ft 70 ft away. What is the downhill grade magnitude?

A. 1.40%
B. 2.00%
C. 2.80%
D. 20.0%

96. Excavation will remove every point placed directly on a proposed curb line. Which staking arrangement best preserves usable line-and-grade reference during construction?

A. Set clearly labeled offset stakes outside the disturbance and record the offset back to design
B. Place all reference stakes directly inside the excavation
C. Use unlabeled stakes wherever they are easiest to drive
D. Rely on the contractor to reconstruct line from memory

97. A reference hub elevation is 755.88 ft. A proposed footing bottom is elevation 752.43 ft. What vertical cut reaches design grade?

A. 3.45 ft cut
B. 3.45 ft fill
C. 2.55 ft cut
D. 4.45 ft cut

98. A retaining-wall batter is 1 horizontal to 12 vertical. Over 9.0 ft of vertical rise, what horizontal offset develops?

A. 9.00 ft
B. 1.33 ft
C. 108.00 ft
D. 0.75 ft

99. A critical anchor-bolt point has been staked from a robotic total-station setup. What is the best immediate verification before concrete placement?

A. Trust the stake because robotic instruments cannot misorient
B. Move the stake to match nearby formwork without checking design
C. Check the point from independent control or an independent setup and compare with the design coordinates
D. Delete the setup notes once the contractor accepts the point

100. A design point lies 45 ft along an alignment from a control point and 18 ft perpendicular to the right. What straight-line distance separates the control and design points?

A. 27.00 ft
B. 48.47 ft
C. 63.00 ft
D. 41.24 ft

Practice Exam 11: Answer Key and Explanations

1. A — Map length is converted to ground distance by multiplying by the stated scale. Thus 5.60 inches times 85 feet per inch equals 476 feet. Dividing by the scale or shifting the decimal does not represent the map-to-ground relationship. The result is appropriate for preliminary route planning before detailed staking or design refinement.

2. B — Primary control should survive the work and remain recoverable throughout the project. Stable points outside excavation, traffic, and demolition provide a dependable framework from which temporary working control can be replaced. Marks on demolition surfaces, lath, or movable pads may be convenient initially, but they are too vulnerable to support repeated construction and verification.

3. D — Relative precision is expressed as traverse length divided by linear misclosure. Solving for misclosure gives 7,350/21,000 = 0.35 foot. Smaller closure is better, while the larger alternatives fail the minimum requirement. Establishing this limit during planning gives the field crew a measurable acceptance criterion for the control observations. Check units and document the result.

4. C — A proportional error of 1.5 ppm equals 1.5 parts in one million of the measured distance. Multiplying 4,800 feet by 1.5 x 10^-6 gives 0.0072 foot. The other answers come from decimal-place errors. This estimate helps determine whether the proposed equipment is adequate for the planned control accuracy. Check units and document the result.

5. B — A vertical survey is only as consistent as its reference system. The crew should know the benchmark, datum, units, and how project control connects to the published network before observations begin. Arbitrary or separate local elevations can be useful only when intentionally authorized and documented. Ellipsoid heights are not automatically interchangeable with project orthometric elevations.

6. D — Along the 900-foot side, locations occur at 0, 150, through 900 feet, giving seven grid lines. Along the 600-foot side there are five lines. Multiplying 7 by 5 gives 35 intersections. Counting only intervals would undercount endpoints, so boundary inclusion must be considered explicitly when estimating field effort. Check units and document the result.

7. A — Traverse geometry must be physically observable. When buildings or other obstructions block direct sight, planned intermediate or offset control can maintain intervisibility and reasonable sight lengths. Better descriptions do not create a line of sight, a single backsight cannot span every obstructed setup, and manually entering coordinates does not replace the observations needed to establish dependable control.

8. C — GNSS depends on clean satellite signal paths. Nearby reflective surfaces can send delayed copies of the same signal to the antenna, producing multipath and degrading the solution. The fence does not change an optical plummet scale, level-rod length, or the project datum. Site reconnaissance should therefore consider obstructions and reflective surroundings before setting permanent GNSS control.

9. B — Independent random uncertainties combine by root-sum-square rather than simple addition. Squaring 0.018 and 0.024, summing, and taking the square root gives 0.030 foot. The simple sum is overly conservative for this stated independent-error model, while subtraction is not appropriate. Planning with the combined value supports a defensible equipment and setup error budget.

10. D — A station equation changes the station label at a physical location but does not inherently change the horizontal reference framework. Planning should preserve a single documented alignment and identify the equation so designers and field crews interpret station values consistently. Separate crew conventions or a new datum would create avoidable ambiguity and could place otherwise correct offsets at the wrong.

11. C — Convert each map dimension independently: 3.25 inches represents 390 feet and 2.40 inches represents 288 feet. Their product is 112,320 square feet. Multiplying the plotted inch values alone would give map area, not ground area. This planning computation helps estimate site size and field coverage before a detailed topographic survey is scheduled.

12. A — Drainage design depends on the actual geometry controlling runoff. Flow lines, banks, pavement edges, culvert inverts, and other grade breaks define changes in slope that a surface model must preserve. A uniform random pattern can miss those changes. Property monuments and photographs may be useful for other purposes, but neither substitutes for measured terrain features and elevations.

13. D — For a small angle, transverse error is approximately distance times angle in radians. Rearranging gives angle = 0.032/2,200 radians. Multiplying by 206,264.806 arcseconds per radian yields about 3.00 arcseconds. This comparison helps determine whether the angular capability and planned sight lengths are compatible with the desired control precision. Check units and document the result.

14. C — A dense point set describes broad surface form, but abrupt slope changes are best constrained with breaklines that explicitly define crests and toes. Without them, triangulation may smooth across the bench geometry even when many points are present. Photographs support interpretation but do not replace controlled measurements. Combining dense coverage with critical breaklines produces a more reliable terrain model.

15. B — Different target configurations can require different constants and height conventions. If those settings are undocumented or changed incorrectly, otherwise precise measurements can receive systematic distance or elevation offsets. The plan should define target types, prism constants, target heights, and reflectorless procedures so every crew uses consistent settings and the office can reconstruct how observations were obtained.

16. A — Different technologies can coexist reliably when they observe common control tied to a documented reference framework. Shared points allow transformations, orientation, and independent checks between GNSS and terrestrial work. Unrelated origins or rotations make later reconciliation harder, while visual CAD matching is not a survey control procedure. A common framework should be established before production data are collected.

17. B — One acre contains 43,560 square feet. Dividing 2,178,000 by 43,560 gives exactly 50 acres. Multiplying instead of dividing or shifting the decimal produces the larger distractors. Converting area during planning helps estimate field coverage, access needs, and deliverable scale while keeping the calculation tied to standard survey units. Check units and document the result.

18. C — With more observations than the mathematical minimum, the survey has internal checks such as closures, residuals, or independent paths. Those checks can reveal a bad sight, transcription error, or weak geometry that a minimally determined network might hide. Redundancy does not guarantee identical readings, eliminate documentation, or make coordinate reference systems interchangeable.

19. D — Dividing 2,600 by 325 gives eight equal intervals. Because a monument is placed at both ends of those intervals, the count is eight plus one, or nine marks. Counting only intervals would omit one endpoint. Planning station counts this way helps estimate monuments, observation time, and field materials before monitoring work begins.

20. A — An assumed system can be perfectly workable when its defining elements are preserved. Future users need the origin, orientation, units, recoverable control, and any later relationship to another coordinate system. Rounded coordinates alone do not define the frame, and labeling an untied system as state plane is misleading. A single setup is not enough to recreate durable project control.

21. D — The rectangular footprint contains 4,200 x 650 = 2,730,000 square feet. Dividing by 43,560 square feet per acre gives about 62.67 acres. The other values reflect incorrect conversion factors or decimal placement. This estimate supports flight planning, coverage checks, and preliminary production budgeting before detailed overlap and terrain requirements are applied.

22. A — Primary control should survive the project and remain available for independent checks. Durable monuments beyond likely disturbance provide that backbone, while convenient working points can be replaced as construction progresses. Control placed in the work zone is vulnerable, and unrelated crew systems make design, staking, and as-built data difficult to reconcile consistently.

23. B — The original ground distance is 2.75 x 200 = 550 feet. Increasing that by 18% gives 550 x 1.18 = 649 feet. Adding 18 feet would misuse the percentage, and leaving the route unchanged ignores the alternative. The calculation is useful when comparing preliminary survey corridors or access alternatives before detailed alignment work begins.

24. C — GIS data can be valuable for reconnaissance and planning, but its positional quality depends on how the source was created. Critical utility conflicts should therefore be verified using records, locating methods, potholing, or survey observations appropriate to the project. Screen display precision does not establish field accuracy, yet rejecting useful background information entirely is also unnecessary.

25. D — Each side represents 4.10 x 70 = 287 feet. A square has four equal sides, so the perimeter is 4 x 287 = 1,148 feet. Using one side alone or confusing perimeter with area produces the distractors. This type of quick scale calculation is useful when planning boundary walks, access, and field crew time.

26. B — Height of instrument is benchmark elevation plus backsight. Adding 5.42 feet to 412.68 feet gives 418.10 feet. Subtraction would move in the wrong direction for the HI method. The HI should then be used consistently for foresights from that setup, with the benchmark identity and reading retained in the field notes for checking.

27. A — A foresight is the vertical difference from the instrument line of sight down to the point elevation. Subtract 411.73 from 418.10 to obtain 6.37 feet. Adding the elevations is physically meaningless for a rod reading, while the other small value reflects using the wrong difference. This rearranges the standard HI relationship.

28. C — A second known control observation tests whether the occupied point, backsight, coordinates, and orientation are all behaving as expected. Merely trusting the controller does not detect a wrong point selection or entered coordinate. Delaying the check risks contaminating many shots, while changing prism height to force agreement would hide rather than diagnose an error.

29. B — With zenith angle measured from vertical, the horizontal component is slope distance times sine of the zenith angle. Thus 642.80 sin 88.5 degrees is about 642.58 feet. Using cosine would produce the small vertical component, while leaving the slope distance unchanged ignores the slight inclination of the sight. Check units and document the result.

30. A — The vertical component of a slope distance with zenith angle measured from vertical is S cos Z. Here 642.80 cos 88.5 degrees is about 16.83 feet. The horizontal component is much larger because the sight is nearly horizontal. Keeping the angle convention clear prevents swapping sine and cosine in trigonometric leveling calculations.

31. C — Convert the four angles to seconds or average the seconds because degrees and minutes are identical. The seconds are 22, 26, 24, and 20, whose mean is 23. Therefore the mean direction is 73 degrees 18 minutes 23 seconds. Repetition improves precision and also provides a simple check for inconsistent observations.

32. D — Because the tape is longer than nominal, each recorded 100-foot tape length covers slightly more ground than indicated. Multiply the measured distance by 100.03/100.00 to obtain about 760.23 feet. Subtracting the correction would apply the sign incorrectly. This illustrates why field measurement conditions and calibration information must be documented. Check units and document the result.

33. C — When backsight and foresight distances are approximately equal, a small line-of-sight error produces nearly equal effects on the two rod readings, so their difference largely cancels. Strongly unbalanced sights do the opposite. Turning points remain necessary where setups change, and using only one stadia hair does not correct collimation. Document the result for checking.

34. B — First establish the instrument line of sight: 245.66 + 4.18 = 249.84 feet. The required rod reading to reach elevation 241.92 is then 249.84 - 241.92 = 7.92 feet. Using the backsight again or subtracting the benchmark directly skips the HI relationship and produces an incorrect field reading. Document the result for checking.

35. A — Start at the occupied-point elevation, add instrument height, add the measured vertical component to the prism, then subtract prism height to reach the target ground point. The calculation is 680.25 + 5.10 + 2.45 - 5.60 = 682.20 feet. Mixing instrument and target heights is a common trigonometric-leveling mistake. Check units and document the result.

36. D — When a rod is rocked toward and away from the instrument, the shortest line-of-sight intercept occurs when the rod is vertical. Therefore the minimum observed reading is accepted. A larger reading indicates the rod is tilted away from the vertical plane. This field technique helps control rod-plumbing error when a rod bubble is unavailable or uncertain.

37. C — The absolute difference is 0.04 foot and the mean is 528.40 feet. Dividing 0.04 by 528.40 and multiplying by 100 gives about 0.00757%, which rounds to 0.0076%. Using one reading rather than the mean changes little here, but the stated comparison uses the average as the reference magnitude. Check units and document the result.

38. A — Switching measurement modes can change how the instrument interprets the return signal and applies target settings. A quick known-distance check confirms the intended mode and exposes an accidental prism-constant or target configuration. Surface properties can influence reflectorless performance, so blindly treating the wall like a prism target is not a dependable field procedure.

39. B — The computed elevation is 0.028 foot below the published benchmark, so a +0.028-foot correction is needed to bring the closing value into agreement. A negative correction would move the result farther away. This is the opposite sign of computed-minus-published misclosure, illustrating why adjustment work must state its sign convention explicitly.

40. D — The east and north offsets are perpendicular components, so their resultant magnitude is found with the Pythagorean theorem. sqrt(0.012^2 + 0.016^2) equals 0.020 foot. Adding the components gives an upper bound, not the vector magnitude. This check quantifies how a centering error can influence observed directions and distances. Check units and document the result.

41. D — The north and west offsets are perpendicular components of one closure vector. Its magnitude is sqrt(0.18^2 + 0.24^2) = 0.30 foot. Algebraically adding signed components would not give the straight-line separation. Plotting the error as orthogonal components provides a useful geometric check on the traverse closure computation. Check signs, units, and rounding before carrying the result into later computations.

42. A — Relative precision is traverse length divided by linear error of closure. Dividing 6,750 feet by 0.27 foot gives 25,000, so the precision is approximately 1:25,000. Reversing the ratio or moving the decimal produces the other choices. The value describes closure quality relative to the size of the traverse, not absolute positional accuracy.

43. C — Latitude is the north-south component, computed as distance times cosine of azimuth measured clockwise from north. For 32 degrees 40 minutes, 920 cos 32.6667 degrees is about +774.48 feet. The sign is positive because the course lies in the northeast quadrant. Sine would instead produce the departure component. Check units and document the result.

44. B — Departure is the east-west component, equal to distance times sine of an azimuth measured from north. Using 920 sin 32.6667 degrees gives about +496.57 feet. The course is in the northeast quadrant, so east departure is positive. Using cosine swaps the component, while a negative sign would place the course in the wrong quadrant.

45. C — A southeast bearing is converted to azimuth by subtracting the bearing angle from 180 degrees. Thus 180 - 27 degrees 15 minutes equals 152 degrees 45 minutes. Using the bearing angle directly would describe a northeast line, while adding to 180 creates southwest orientation. Quadrant identification is the essential first step.

46. D — An azimuth between 270 and 360 degrees lies in the northwest quadrant. The bearing angle is measured from north, so subtract the azimuth from 360 degrees: 360 - 286 degrees 20 minutes = 73 degrees 40 minutes. The direction is therefore N 73 degrees 40 minutes W. The other quadrants misstate orientation.

47. A — The coordinate differences are 440 feet east and 330 feet north. The horizontal distance is sqrt(440^2 + 330^2) = 550 feet. Adding the coordinate differences gives 770 feet, while using either component alone gives the other distractors. Coordinate distance is always based on the perpendicular east and north differences between points.

48. B — The coordinate changes are +440 east and +330 north, placing the line in the northeast quadrant. Azimuth measured clockwise from north is atan2(departure, latitude), or atan2(440,330) = 53.13 degrees. Using the complementary angle gives 36.87 degrees, while adding 90 or 180 degrees moves the line into another quadrant. Check units and document the result.

49. B — The observed total is 16 arcseconds less than 360 degrees, so +16 arcseconds must be added to reach the theoretical sum. A negative correction would worsen the deficiency, while +4 arcseconds is only the per-angle correction if the total is later distributed equally among four measured angles. Check signs, units, and rounding before carrying the result into later computations.

50. C — The measured angles are collectively 16 arcseconds too small, so the corrections must add 16 arcseconds to the total. Equal distribution across four angles gives +4 arcseconds to each. Applying -4 would worsen the misclosure, while +8 or +16 would overcorrect. Adjustment signs should oppose the observed closure error. Check units and document the result.

51. D — Bowditch weighting is proportional to course length. Dividing 780 by the total 3,900 feet gives 0.20, or 20 percent. Therefore this course receives 20 percent of the total latitude correction, with the correction sign determined separately by the misclosure. The other percentages do not reflect the stated length proportion. Document the result for checking.

52. A — The total closing error is +0.036 foot, so the accumulated correction must be -0.036 foot. Dividing equally among 18 setups gives -0.002 foot per setup increment. The correction sign opposes the closure. Equal-by-setup distribution is appropriate only when that method is specified; other projects may weight corrections by distance or another criterion.

53. B — When vertical angle is measured from the horizontal, the horizontal component equals slope distance times cosine of the vertical angle. Using 1,025 cos 6 degrees 20 minutes gives about 1,018.74 feet. Sine produces the vertical component, and retaining the full slope distance ignores the inclination. Always identify the angle convention before resolving components.

54. C — With the angle referenced from horizontal, the vertical component is S sin v. Therefore 1,025 sin 6 degrees 20 minutes is about +113.07 feet. The positive sign follows the upward vertical angle. Cosine would give the horizontal component, while a negative value would correspond to a downward sight under the stated convention.

55. A — Rearrange the tangent relation T = R tan(Delta/2) to R = T/tan(Delta/2). Substituting T = 317.80 feet and Delta = 41 degrees gives approximately 850 feet. Using arc length as the radius or multiplying by the tangent factor rather than dividing does not satisfy the circular-curve geometry. Check signs, units, and rounding before carrying the result into later computations.

56. D — Arc length for a simple circular curve is L = pi R Delta/180 when Delta is in degrees. Substituting 850 feet and 41 degrees gives about 608.25 feet. The tangent length is a different quantity, and doubling the arc is not justified. Keeping radius, angle, and stationing quantities distinct avoids common horizontal-curve errors.

57. C — The PC lies one tangent length before the PI along increasing station. Subtracting 317.80 feet from station 38+75.00, or 3,875.00 feet, gives 3,557.20 feet, written 35+57.20. Adding the tangent would locate the forward tangent point rather than the PC. Station arithmetic should be performed in total feet first. Check units and document the result.

58. A — The PT station equals the PC station plus the curve length. Using PC = 35+57.20 and L = 608.25 feet gives 4,165.45 feet, or station 41+65.45. Adding curve length directly to the PI would be incorrect because stationing follows the arc from the PC, while the PI lies off the curve.

59. B — Grade changes linearly along a parabolic vertical curve. The algebraic grade change is -4.0 percentage points over 500 feet. At 175 feet, the change is -1.4 points, so the grade is +2.4 - 1.4 = +1.0%. Using the total grade change or the wrong sign produces the distractors. Check units and document the result.

60. D — Use E = E_PVC + g1 x + A x^2/(2L). The tangent rise is 0.024(175) = 4.20 feet. The parabolic correction is (-0.040)(175^2)/(1,000) = -1.225 feet. Adding these to 744.20 gives 747.175 feet, which rounds to 747.18 feet using the stated two-decimal result. Check units, signs, quadrants, and rounding before carrying the result into the next coordinate or adjustment step.

61. C — The high point occurs 300 feet from the PVC on a 500-foot curve. Dividing 300 by 500 gives 0.60, or 60 percent of the curve length. The percentage simply expresses the already determined zero-grade location as a fraction of total curve length and provides a useful reasonableness check. Check signs, units, and rounding before carrying the result into later computations.

62. A — The area is 285.6 x 418.3 = 119,454.48 square feet. Dividing by 43,560 square feet per acre gives approximately 2.743 acres. The alternative values reflect transposed digits or decimal errors. Coordinate or dimension-based area should be carried with sufficient precision before final conversion and reporting. An independent arithmetic or geometric check helps distinguish a computation mistake from actual measurement misclosure.

63. D — Triangle area is one-half base times perpendicular height. One-half of 240 times 135 equals 16,200 square feet. Omitting the one-half factor doubles the answer, while using unrelated combinations of the dimensions produces the other distractors. The perpendicular height, not a sloping side length, is the required dimension for this area formula.

64. B — The trapezoid area formula uses the average of the two parallel widths. Adding 30 and 18 gives 48 feet, and dividing by two gives an average width of 24 feet. Multiplying that average by the perpendicular depth would then produce area. Using the depth itself or the unaveraged sum skips a required step.

65. B — Average end area is (144 + 216)/2 = 180 square feet. Multiplying by the 80-foot interval gives 14,400 cubic feet, and dividing by 27 gives 533.33 cubic yards. Forgetting the cubic-foot conversion or failing to average the end areas produces the other values. Keep volume units explicit through each step.

66. D — For azimuth measured clockwise from north, departure is D sin azimuth and latitude is D cos azimuth. At 125 degrees, the departure is positive east and the latitude is negative south. Adding those components to the starting coordinates gives approximately E 8,544.89 and N 3,693.51 feet. Quadrant signs are essential.

67. A — For a southeast bearing, the departure is east and therefore positive. The east component is 425 sin 35 degrees, about 243.77 feet. Adding that to easting 6,120.00 gives E 6,363.77 feet. Subtracting would place the course west, while using cosine would incorrectly substitute the north-south component. Check units and document the result.

68. C — A southeast course has a negative latitude because it travels south. The south component magnitude is 425 cos 35 degrees, about 348.14 feet. Subtracting from N 9,400.00 gives N 9,051.86 feet. Adding would move north, and using sine would substitute the east-west component instead of the required latitude. Check units and document the result.

69. B — Rounding is necessary when reporting results, but applying it too early can accumulate small numerical changes through a sequence of coordinate, curve, or grade calculations. Retaining additional working precision preserves the information available from the observations. Final displayed precision should still be appropriate to the measurement quality and project requirements rather than simply showing every calculator digit.

70. A — The station difference is 380 feet and the elevation rise is 5.70 feet. Grade equals rise divided by horizontal run: 5.70/380 x 100 = +1.50%. The positive sign follows increasing elevation with increasing station. A plan/profile check should also confirm that no vertical curve or grade break occurs between the endpoints.

71. D — Under the stated uniform-slope assumption, elevation changes proportionally with horizontal distance between adjacent contours. One-quarter of the 2-foot contour interval is 0.5 foot, so point P is elevation 612.5 feet. Using one-half or three-quarters of the interval would correspond to different positions between the same contour lines. Check units and document the result.

72. C — An engineering scale is ground distance divided by plotted inches. Dividing 392 feet by 7.84 inches gives 50 feet per inch, so the scale is 1 inch = 50 feet. Multiplying the quantities would not produce a scale denominator. This inverse check is useful when verifying an unlabeled or suspect print scale.

73. B — For a map with one contour interval, closely spaced contours mean the same elevation change occurs over a shorter horizontal distance, so the terrain is steeper. Wide spacing indicates gentler slope.

Contour spacing does not by itself change the datum or contour interval. Interpreting this relationship is fundamental when reading terrain shape from a topographic map.

74. C — Vertical exaggeration is the horizontal scale denominator divided by the vertical scale denominator when both are expressed in equivalent units. Here 100/20 = 5, so vertical features are shown five times more prominently than they would be at equal scales. This exaggeration helps reveal grade changes but must be remembered when visually judging slope.

75. D — Area scales by the square of the linear scale. One square inch represents 80^2 = 6,400 square feet, and 12.5 square inches represents 80,000 square feet. Multiplying by only 80 would treat an area as a length. Map-area conversions therefore require squaring the linear scale factor before applying it. Check units and document the result.

76. A — A ditch flow line represents a terrain discontinuity that should guide the surface triangulation. Including it as a breakline prevents triangles from crossing the channel in ways that artificially smooth or misplace the low point. The breakline does not alter scale, guarantee measurement accuracy, or eliminate the need for sufficient elevations defining the surrounding ground.

77. A — The elevation change is 30 feet over 375 feet horizontally. Average slope is 30/375 x 100 = 8.0%. The 6-foot contour interval helps describe the map but is not itself the slope percentage. Converting rise over run to percent provides a quantitative check on the visual contour spacing and terrain steepness.

78. B — Maps should make vertical reference information unambiguous. If published and assumed elevations coexist, users must be able to tell which datum or local system applies to each value. Similar symbols without notes invite systematic mistakes. Averaging unrelated datums has no meaning, and numerical size does not determine accuracy. Clear labels preserve the survey reference framework.

79. D — At the stated scale, 4.40 inches represents 176 feet. Compared with the intended 180 feet, the plotted line is 4.0 feet short in ground-equivalent distance. Converting the observed plot length back to ground units makes the discrepancy understandable. The result may indicate print scaling, drafting, or measurement issues requiring further review.

80. C — Numerical display should reflect the quality and purpose of the underlying data. Printing many unnecessary decimals can suggest a level of positional certainty that the field methods, control, or plotting scale do not support. Extra digits do not improve the observations or change the datum. Appropriate precision communicates survey quality more honestly and reduces false confidence.

81. B — A 1.20% grade means 0.012 foot of vertical change per foot of horizontal run. Over 350 feet, the drop is 350 x 0.012 = 4.20 feet. The starting invert is unnecessary when only the change is requested. Keeping percent grade in decimal form prevents a hundredfold error. The staking record should preserve the reference, station, offset, and check used.

82. D — The rise is 4.20 feet and the horizontal station difference is 280 feet. Grade equals 4.20/280 x 100 = +1.50%. The positive sign reflects increasing elevation with increasing station. The result can be used for intermediate staking only if the plans confirm a constant grade without a vertical curve or grade break.

83. A — Cross-slope magnitude is vertical difference divided by horizontal offset. Dividing 0.28 foot by 14 feet and multiplying by 100 gives 2.00%. The direction would be negative if the project convention assigns a negative sign to falling away from centerline, but the question asks only for magnitude. Keep offset and elevation units consistent.

84. C — A station equation changes station nomenclature at one physical point without necessarily changing the horizontal alignment. The crew must determine whether a requested station is before or after the equation so it can locate the correct physical position. The equation does not automatically alter the datum, reverse offsets, or introduce a geometric gap in the centerline.

85. A — From station 20+00 to 23+65 is 365 feet along the alignment. Because the line runs due east, easting increases by 365 feet and northing remains unchanged. The point is therefore E 5,365.00, N 8,000.00 feet. A northing change would correspond to a different alignment direction, not the stated eastbound tangent.

86. C — Facing east, the left side of the alignment is north. Therefore a 22-foot left offset increases northing by 22 feet while leaving easting unchanged at the perpendicular station point. The stake coordinates are E 5,365.00, N 8,022.00 feet. Correctly relating left and right to alignment direction is essential in coordinate stakeout.

87. B — The simple-curve tangent length is T = R tan(Delta/2). With R = 620 feet and Delta = 36 degrees, T = 620 tan 18 degrees, or approximately 201.45 feet. The arc length is a different quantity, and doubling the tangent does not define one tangent distance from the PI to PC or PT.

88. D — Convert the two stations to feet and subtract: 5,240.00 - 5,038.55 = 201.45 feet. That difference is the tangent distance from PC to PI along the back tangent. Adding the station values or substituting the curve arc length would represent different quantities. Station arithmetic is simplest when first converted to total feet.

89. C — Curve length is L = pi R Delta/180 for Delta in degrees. Substituting 620 feet and 36 degrees gives about 389.56 feet. The tangent length is shorter and belongs to a different formula. Doubling the arc is unjustified. Correct stationing uses this arc length from PC to PT along the curved alignment.

90. A — PT station equals PC station plus the arc length. Adding 389.56 feet to station 50+38.55, or 5,038.55 feet, gives 5,428.11 feet, written 54+28.11. The PI station is not used directly in this final station addition because stationing follows the curve from the PC. Stake markings must distinguish design grade from existing ground and make the intended construction action unambiguous.

91. D — Grade varies linearly along the parabolic vertical curve. The total grade change is +3.0 percentage points over 360 feet. At 120 feet, one-third of the curve length, the grade has increased by 1.0 point from -2.0% to -1.0%. This intermediate grade describes the tangent slope to the curve at that station.

92. B — Use the parabolic curve equation. The initial tangent term is -0.02(120) = -2.40 feet. The parabolic correction is 0.03(120^2)/(720) = +0.60 foot. Therefore the curve elevation is 680.00 - 2.40 + 0.60 = 678.20 feet. The correct computation must include both terms. Critical layout should be checked from independent control before construction proceeds so a setup error is not propagated.

93. C — A rectangular grid diagonal follows the Pythagorean theorem. sqrt(72^2 + 96^2) = 120 feet. Comparing measured diagonals with this design value is a practical independent check on squareness after corners are laid out. Equal side lengths alone do not prove that the included angles are 90 degrees, so diagonal checks add useful redundancy.

94. D — The invert is specified below the reference elevation, so subtract the vertical separation: 402.15 - 7.80 = 394.35 feet. Adding would place the invert above the centerline reference, contrary to the stem. The stake or cut sheet should identify the exact reference surface so the contractor does not apply the vertical offset to the wrong point.

95. B — The elevation drop is 1.40 feet over 70 feet horizontally. Grade magnitude is 1.40/70 x 100 = 2.00%. If a signed convention were requested, the direction from the higher point to the lower point would be negative. The question asks magnitude, so the positive percentage is appropriate for the construction slope check.

96. A — Offset stakes move the physical reference away from work likely to destroy a point while preserving a documented relationship back to the design feature. The stake should state offset distance, direction, and relevant grade information. Points inside excavation are vulnerable, unlabeled stakes are ambiguous, and memory is not a reproducible construction-survey record.

97. A — The design footing bottom is below the reference hub, so the required construction action is a cut. Subtracting 752.43 from 755.88 gives 3.45 feet. A fill label would reverse the intended direction. The field note should also identify whether the elevation applies to footing bottom, mud slab, or another construction surface.

98. D — A batter of 1 horizontal to 12 vertical means one foot of horizontal movement for every 12 feet of vertical rise. For 9 feet vertically, the offset is 9/12 = 0.75 foot. Multiplying instead of dividing would greatly overstate the offset. The direction of batter must also be marked clearly in field layout.

99. C — Critical layout deserves an independent check because a wrong setup, backsight, prism height, or coordinate entry can affect every stake from one orientation. Observing the point from independent control provides evidence that the layout is reproducible. Instrument automation does not eliminate human or setup errors, and existing formwork should not override unchecked design coordinates.

100. B — The along-line and perpendicular offset are orthogonal components. The direct distance is sqrt(45^2 + 18^2), approximately 48.47 feet. Simply adding the components gives 63 feet and does not represent the diagonal. This calculation can support an independent tape or EDM check of a construction offset when geometry allows. Check units and document the result.