PRACTICE EXAM 8: CALIFORNIA CIVIL ENGINEERING SURVEYING (100 QUESTIONS)

This 100-question practice exam follows the BPELSG Civil Engineering Surveying Job Analysis-2022 allocation: 25% Survey Planning, 15% Field Data Collection, 30% Data Analysis and Evaluation, 10% Mapping, and 20% Construction Surveying. Use this set as a timed simulation and select the single best answer for each question.

1. A freeway interchange reconstruction will remove several existing project control marks during the first grading phase. Which control plan best preserves survey continuity through the project?

A. Establish redundant primary control outside the disturbance limits and tie working control back to it
B. Place all control on temporary paving scheduled for removal during grading
C. Let each trade establish independent control without a common project reference
D. Depend only on machine-control files because physical recovery marks are unnecessary

2. Historic drainage plans use an assumed benchmark elevation, while a new design survey is tied to a published vertical datum. Before the datasets are combined, what is required?

A. Average the old and new benchmark elevations to create a common value
B. Relabel both files with the new datum name without changing elevations
C. Determine and document a reliable vertical relationship between the two elevation systems
D. Use the old elevations for earthwork and the new elevations for structures with no tie

3. A settlement-monitoring program must detect movement of approximately 0.015 ft. Which planning criterion is most important when choosing the observation method?

A. The instrument display should show at least four decimal places regardless of field conditions
B. Only one observation should be made so averaging does not conceal actual movement
C. The selected instrument should have the longest advertised range even if precision is inadequate

D. The combined survey uncertainty should be meaningfully smaller than 0.015 ft and supported by repeat checks

4. A topographic survey covers a wooded hillside where dense vegetation blocks many ground observations. Which acquisition strategy best supports a reliable terrain model?

A. Interpolate the entire hillside from a few roadway shots without supplemental observations

B. Combine appropriately controlled remote sensing with targeted ground shots and breaklines at critical terrain features

C. Use an old small-scale map as the sole surface source because field access is difficult

D. Delete breaklines so the surface model can smooth naturally through channels and ridges

5. During reconnaissance for a mountain pipeline route, what information most directly affects the choice between GNSS and terrestrial control methods?

A. The contractor's preferred plan-sheet colors and annotation fonts

B. The expected number of sheets in the final construction drawing package

C. Satellite visibility, intervisibility, access, safety constraints, and locations suitable for durable monuments

D. A predetermined decision to minimize the number of control points regardless of terrain

6. What is the principal planning purpose of a route survey for a proposed roadway corridor?

A. Determine legal parcel boundaries for every property adjoining the corridor

B. Establish and document horizontal and vertical information needed to evaluate and design an alignment

C. Replace all project control with temporary stakes placed along the centerline

D. Produce only a photographic record without measured positions or elevations

7. A short site survey intentionally uses an assumed coordinate origin of N 10,000.00 ft, E 5,000.00 ft. What is the best practice?

A. Clearly label the system as assumed and preserve the origin, orientation, and benchmark definition in the records

B. Describe the coordinates as state-plane values because the numbers appear sufficiently large

C. Change the assumed origin between crews to keep all working coordinates positive

D. Omit the coordinate-system description because only relative distances will be used

8. A GIS layer of underground utilities was compiled from records of mixed age and accuracy. How should it be used when planning excavation staking?

A. Assume every mapped line is survey-grade because it appears in a GIS

B. Move design features to match the GIS without checking the layer's source or accuracy

C. Ignore all GIS information because geographic databases have no engineering use

D. Treat it as planning information and verify critical utility locations with appropriate field investigation before relying on them

9. A control network will support both design mapping and later construction staking. Which feature most improves reliability if one monument is disturbed?

A. One highly precise monument with no independent check or backup

B. Redundant observations and multiple independently recoverable control points tied to the same reference

C. Separate coordinate systems for design and construction with no documented transformation

D. A rule that every setup must occupy the same single monument throughout the project

10. Repeated measurements of one distance agree within 0.002 ft, but all are 0.050 ft too long because of an incorrect prism constant. Which statement best describes the observations?

A. They are accurate but not precise

B. They are both accurate and precise

C. They are neither accurate nor precise because repeated values are close

D. They are precise but not accurate

11. A project must transfer a benchmark across a wide river where balanced conventional level sights are impractical. Which plan is most defensible?

A. Take one very long foresight from one bank and accept the displayed reading without a check
B. Estimate the elevation difference from the water surface because both banks share the same river
C. Use a suitable precise transfer method with reciprocal or redundant observations and an independent closure check
D. Create a new benchmark elevation on the far bank without relating it to existing vertical control

12. For a deformation survey of a retaining wall, where should reference monuments be located?

A. On stable ground outside the expected zone of wall or soil movement
B. On the wall itself so every reference moves with the structure
C. Inside the excavation where settlement is most likely to occur
D. On temporary formwork because it is closest to the monitored points

13. A proposed storm-drain alignment crosses an area containing mapped gas, electric, and communications facilities. What should the survey plan emphasize before final design elevations are accepted?

A. Field verification of critical utility positions and elevations at potential conflict locations
B. Assuming record depths are exact wherever utility maps show a dimension
C. Ignoring utilities until construction because only the final contractor needs them
D. Changing the project datum so the proposed drain appears clear of the mapped utilities

14. Why are breaklines planned for a topographic surface model at curb returns, ditch flowlines, and retaining-wall edges?

A. They increase the number of contour labels without affecting the modeled surface
B. They eliminate the need for any elevation observations near the feature
C. They convert all measured elevations to a different vertical datum automatically
D. They force the surface model to honor abrupt or linear changes in terrain geometry

15. A downtown control survey has severe overhead obstruction but good intervisibility along sidewalks. Which primary approach is generally most suitable?

A. Use RTK GNSS exclusively beneath the obstruction because multipath improves with nearby buildings

B. Use only handheld mapping coordinates because line-of-sight measurements are unnecessary

C. Use terrestrial traverse or resection methods tied to suitable control, with GNSS used only where conditions support it

D. Avoid establishing control and rely on dimensions scaled from existing plan sheets

16. Before collecting production observations with a total station, why should the project plan include a known-distance or control check?

A. To guarantee that every later observation is exact regardless of field conditions

B. To detect setup, instrument, prism, or reference errors before they propagate through the survey

C. To replace the need for instrument calibration and maintenance records

D. To prove that the selected coordinate datum matches every outside mapping source

17. Two design teams will exchange coordinates for the same site, but one file is in a local grid and the other is in a geodetic coordinate system. What should be planned before exchange?

A. A simple renaming of coordinate columns so both files use the same headings

B. A rule that whichever file has larger coordinate numbers is treated as controlling

C. Independent translations chosen by each designer until plotted features appear close

D. A documented transformation or common control relationship, including units and reference definitions

18. A temporary benchmark is needed beside a year-long building project. Which location is best?

A. A stake inside the planned footing excavation because it is close to the work

B. A loose curb stone likely to be replaced during site improvements

C. A durable object outside likely excavation, vibration, settlement, and equipment traffic, with a clear description

D. A mark on movable construction fencing because it remains visible to crews

19. When planning a closed traverse around a large industrial site, which geometry generally provides a stronger network?

A. Well-distributed stations with reasonably balanced line lengths and angles, plus closure to known control

B. Very short lines clustered at one corner with one extremely long closing side

C. Nearly collinear stations that minimize turning angles throughout the traverse

D. A single open sequence that never returns to or checks against known control

20. A local construction grid will be rotated relative to state-plane north to simplify building layout. What information must be preserved?

A. Only the first stake coordinate because all later points can be reconstructed visually

B. The rotation, origin, units, and relationship between the construction grid and the controlling project coordinates

C. A statement that grid north equals true north even though the grid was intentionally rotated

D. No transformation details as long as the contractor uses the same CAD drawing

21. For a design team preparing proposed improvements, which description correctly separates existing-condition mapping work from later field layout of the approved design?

A. Topographic surveying establishes only legal boundaries, while construction staking creates new property rights

B. Topographic surveying uses elevations only, while construction staking uses horizontal coordinates only

C. The two activities are identical because both use the same instruments and control points

D. Topographic surveying documents existing conditions for design, while construction staking transfers proposed design geometry to the field

22. A contractor requests offset stakes because excavation will destroy stakes set directly on a proposed wall line. What should the survey plan require?

A. Documented offset distance and direction referenced to the same control and design line, with enough information for recovery

B. Random offsets chosen by each crew without recording how they relate to the wall

C. Offsets measured from existing features that have not been surveyed or checked

D. A new coordinate system for every offset stake so direct-line coordinates remain hidden

23. Photogrammetric mapping will be used for a large site. Why is ground control or another verified georeferencing method still important?

A. It is needed only to choose the final drawing colors and contour line weights

B. It guarantees that vegetation and hidden ground surfaces will always be mapped correctly

C. It ties image-derived geometry to the project's horizontal and vertical reference and supports accuracy checks

D. It replaces the need to evaluate camera geometry, overlap, or image quality

24. A survey specification calls for a tighter positional tolerance than the crew's usual procedure can reliably achieve. What is the best planning response?

A. Keep the usual method and report extra decimal places to imply greater precision

B. Revise the method, control, equipment, observation redundancy, or environmental constraints so expected uncertainty meets the requirement

C. Collect the same observations faster because shorter field time reduces all survey error

D. Ignore the tolerance if the plotted result appears acceptable at the final map scale

25. Before accepting a survey plan for a complex site, what is the best way to define completion criteria?

A. State only the final file format because technical checks can be decided after fieldwork

B. Require the fewest possible observations so no conflicting measurements can occur
C. Let each crew decide independently what accuracy is adequate after data collection begins
D. Specify required deliverables, control references, tolerances, checks, and how unresolved discrepancies will be handled

26. A reflector observation crosses a nearly horizontal sight line: S = 684.25 ft and z = 93°20' measured from zenith. Reduce the observation to its horizontal component.

A. 683.09 ft
B. 684.25 ft
C. 39.78 ft
D. 681.09 ft

27. From BM elevation 412.680 ft, a leveling setup reads BS 5.224 ft and then FS 7.931 ft on TP1. Compute the elevation carried to TP1.

A. 425.835 ft
B. 409.973 ft
C. 415.387 ft
D. 399.525 ft

28. The measured line from instrument to prism is 455.60 ft long and inclines upward 6°35' above horizontal. Determine only the rise from instrument axis to prism center.

A. -52.23 ft
B. 452.60 ft
C. +52.23 ft
D. +6.58 ft

29. The height of instrument for a level setup is 633.742 ft. A foresight to a proposed grade point reads 4.386 ft. What is the point elevation?

A. 629.356 ft
B. 638.128 ft
C. 628.970 ft
D. 633.304 ft

30. A field layout file gives direction 214°18' clockwise from north. Express that direction in quadrant-bearing notation for the crew.

A. N 34°18' W
B. S 34°18' W
C. S 55°42' W
D. N 55°42' E

31. Two equivalent face observations reduce to 47°16'42" and 47°16'54". Using both observations equally, determine the adopted horizontal angle.

A. 47°16'42"
B. 47°16'54"
C. 47°17'36"
D. 47°16'48"

32. One full 100.00-ft steel tape length is laid when the tape temperature is 92°F; its standard temperature is 68°F and $\alpha = 0.00000645/°F$. Determine the thermal correction to the measured length.

A. -0.0155 ft
B. +0.1548 ft
C. +0.0155 ft
D. +0.0015 ft

33. For a 2,460-ft EDM observation, isolate only the 3.0-parts-per-million portion of the stated distance uncertainty. What linear amount does that scale term represent?

A. 0.0008 ft
B. 0.0738 ft
C. 0.7380 ft
D. 0.0074 ft

34. A prism actually has a -30 mm constant, but the total station is configured for 0 mm. What is the principal effect on observations to that prism?

A. Only random horizontal-angle noise will increase
B. A systematic distance offset will be introduced into reflector measurements
C. The project vertical datum will automatically shift by 30 mm
D. No measurable effect occurs unless the sight exceeds 1,000 ft

35. An RTK rover near tall structures changes from fixed to float status while locating a critical anchor-bolt control point. What should the crew do?

A. Do not accept the float coordinate for critical control; restore a fixed solution or use another checked method
B. Average several float positions and label the average as fixed
C. Accept the point if the coordinate display shows enough decimal places
D. Assume the nearby structures improve ambiguity resolution and continue staking

36. An instrument is set over elevation 525.360 ft with HI = 5.10 ft. It observes a prism at +4°10', slope distance 312.40 ft, prism height 6.00 ft. What is the prism-ground elevation?

A. 548.058 ft
B. 501.762 ft
C. 547.158 ft
D. 836.034 ft

37. Field notes for a closed level run show start elevation 288.614 ft, ΣBS 36.782 ft, and ΣFS 35.945 ft. The accepted closing benchmark is 289.468 ft. Compute observed-minus-known closure.

A. -0.017 ft
B. +0.017 ft
C. +0.837 ft
D. 289.451 ft

38. Using rectangular coordinates, determine the straight-line separation between setup point (N 6,150.00, E 9,325.00) and layout point (N 6,412.00, E 9,108.00), in feet.

A. 262.00 ft
B. 217.00 ft
C. 479.00 ft
D. 340.20 ft

39. A sight line rises at an elevation angle of 2°45'. What percent grade corresponds to that angle?

A. 2.75%
B. 4.80%
C. 5.24%
D. 0.05%

40. After setting up on known control and backsighting another known point, what field check is most useful before collecting a large batch of detail points?

A. Change the coordinate system if the first detail point does not match the drawing
B. Assume the setup is correct because the data collector accepted the occupation
C. Reobserve the backsight or a third known point and compare the measured direction and distance with known values
D. Delay every control check until the end of the day so production is not interrupted

41. A southeast traverse leg measures 538.70 ft on azimuth 146°20'. When the leg is resolved into rectangular components, what latitude (ΔN) results?

A. -448.35 ft
B. +298.63 ft
C. +448.35 ft
D. -298.63 ft

42. Resolve that same 538.70-ft, azimuth-146°20' traverse leg into its departure component. What is ΔE?

A. -448.35 ft
B. +298.63 ft
C. -298.63 ft
D. +448.35 ft

43. A traverse begins at N 12,000.00 ft, E 8,450.00 ft and runs 538.70 ft at azimuth 146°20'. What are the endpoint coordinates?

A. N 12298.63 ft, E 8001.65 ft
B. N 12448.35 ft, E 8151.37 ft
C. N 12448.35 ft, E 8748.63 ft
D. N 11551.65 ft, E 8748.63 ft

44. A closed traverse has accumulated coordinate misclosures of +0.18 ft in northing and -0.24 ft in easting. What is the linear error of closure?

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

45. The sum of traverse course lengths is 4,850 ft and the coordinate closure vector has magnitude 0.30 ft. Express the closure quality as a conventional 1:N precision ratio.

A. 1:4,850
B. 1:970
C. 1:16,167
D. 1:1,617

46. A Bowditch adjustment is being applied to a 3,600-ft traverse whose total latitude misclosure is +0.25 ft. Determine the latitude correction assigned to a 720-ft leg.

A. +0.050 ft
B. -0.250 ft
C. +0.010 ft
D. -0.050 ft

47. A traverse line has forward azimuth 72°40'. At the next station, a clockwise angle to the following line is 113°25'. What is the next forward azimuth?

A. 186°05'
B. 40°45'
C. 319°15'
D. 246°05'

48. Which azimuth is equivalent to the bearing N 27°35' W?

A. 27°35'
B. 332°25'
C. 152°25'
D. 207°35'

49. Compute the enclosed plan area from these consecutive local vertices, in feet: (0,0), (180,20), (230,145), (80,210), (-25,95).

A. 17,762.5 sq ft
B. 35,525.0 sq ft
C. 71,050.0 sq ft
D. 31,500.0 sq ft

50. For roadway curve design, R = 650 ft and the intersection/central angle is 44°. Determine the distance from PI to either tangent point.

A. 262.62 ft
B. 499.16 ft
C. 486.99 ft
D. 51.05 ft

51. The centerline follows a 650-ft-radius circular arc through 44°. How much stationing is consumed by the curved arc itself?

A. 262.62 ft
B. 486.99 ft
C. 499.16 ft
D. 51.05 ft

52. For the same curve, what is the long chord from PC to PT?

A. 499.16 ft
B. 262.62 ft
C. 51.05 ft
D. 486.99 ft

53. For the same curve, what is the external distance?

A. 262.62 ft
B. 51.05 ft
C. 499.16 ft
D. 486.99 ft

54. If the PC of the 650-ft radius, 44° curve is at station 125+40.00, what is the PT station?

A. 130+39.16
B. 129+84.22
C. 130+40.00
D. 131+39.22

55. A 44° circular curve is staked from the PC. What tangent deflection is used to sight the point halfway along the curve arc?

A. 22°00'
B. 44°00'
C. 5°30'
D. 11°00'

56. A crest curve starts at PVC elevation 710.000 ft. Over L = 600 ft, grade changes from +1.8% to -1.2%. Compute the parabolic-curve elevation at x = 300 ft.

A. 715.400 ft
B. 711.500 ft
C. 713.150 ft
D. 713.250 ft

57. For the same vertical curve, what is the constant rate of grade change per foot?

A. -0.0000500 per ft

B. -0.0300000 per ft
C. +0.0000500 per ft
D. -0.0005000 per ft

58. For the 600-ft curve changing from +1.8% to -1.2%, locate the zero-grade point by its distance x from the PVC.

A. 240.0 ft
B. 300.0 ft
C. 450.0 ft
D. 360.0 ft

59. Two points are 500.00 ft apart horizontally and differ in elevation by 36.00 ft. What is the slope distance between them?

A. 536.00 ft
B. 501.29 ft
C. 498.70 ft
D. 501.30 ft

60. Over 425 ft of horizontal run, a proposed pipe centerline changes from elevation 326.90 ft to 318.40 ft. Express the signed longitudinal slope as a percent.

A. +2.00%
B. -0.50%
C. -2.00%
D. -8.50%

61. Between stations 10+00 and 14+00, a tangent profile rises uniformly from EL 250.00 ft to EL 258.00 ft. Interpolate the tangent elevation at station 11+75.

A. 252.00 ft
B. 253.50 ft
C. 254.00 ft
D. 256.50 ft

62. A level route has +0.024 ft misclosure distributed in proportion to distance. What correction applies at a point 3.0 miles from the start on an 8.0-mile route?

A. +0.009 ft
B. -0.024 ft
C. -0.003 ft
D. -0.009 ft

63. Three independent horizontal-distance observations are 301.42 ft, 301.38 ft, and 301.40 ft. If they are equally weighted, what mean distance is reported?

A. 301.40 ft
B. 301.38 ft
C. 301.42 ft
D. 904.20 ft

64. From a known point, a side shot is 420.00 ft at azimuth 305°00'. What are its coordinate changes?

A. ΔN = -344.04 ft, ΔE = +240.90 ft
B. ΔN = -240.90 ft, ΔE = 344.04 ft
C. ΔN = +240.90 ft, ΔE = -344.04 ft
D. ΔN = +240.90 ft, ΔE = 344.04 ft

65. A proposed north-south centerline has easting 7,250.00 ft. An east-west centerline has northing 3,880.00 ft. What are the coordinates of their intersection?

A. N 3,880.00 ft, E 7,250.00 ft
B. N 7,250.00 ft, E 3,880.00 ft
C. N 3,880.00 ft, E 3,880.00 ft
D. N 7,250.00 ft, E 7,250.00 ft

66. A trapezoidal excavation plan area has parallel sides 140 ft and 210 ft separated by a perpendicular distance of 95 ft. What is the area?

A. 33,250 sq ft
B. 14,250 sq ft
C. 19,950 sq ft
D. 16,625 sq ft

67. A project uses combined scale factor 0.999920. Reduce a 1,250.000-ft horizontal ground line to its corresponding grid length.

A. 1,250.100 ft
B. 1,249.000 ft
C. 1249.900 ft
D. 1,250.920 ft

68. A straight alignment runs due east along northing 5,600.00 ft. A feature is at N 5,572.50 ft. What is its signed perpendicular offset if left of increasing station is positive?

A. +27.50 ft
B. -27.50 ft
C. -5,572.50 ft
D. +5,600.00 ft

69. A measured site area is 108,900 square feet. Approximately how many acres is that?

A. 1.50 acres
B. 2.00 acres
C. 2.50 acres
D. 4.00 acres

70. Earthwork sections 100 ft apart have excavation areas 620 sq ft and 980 sq ft. Estimate the intervening quantity in cubic yards by average end area.

A. 2,296.3 cu yd
B. 2,963.0 cu yd
C. 5,925.9 cu yd
D. 800.0 cu yd

71. A wall occupies 6.35 inches on a drawing whose stated scale is 50 ground feet per plotted inch. Determine the wall's represented ground length.

A. 317.5 ft
B. 127.0 ft
C. 635.0 ft
D. 56.35 ft

72. A 420-ft ground distance is shown as 7.00 inches on a plan. What is the plan scale?

A. 1 inch = 42 ft
B. 1 inch = 70 ft
C. 1 inch = 420 ft
D. 1 inch = 60 ft

73. Spot elevations 516.0 ft and 524.0 ft are 64 ft apart on a straight uniform slope. How far from the 516.0-ft point is the 520-ft contour?

A. 16 ft
B. 40 ft
C. 32 ft
D. 48 ft

74. On the same contour map, which area generally represents the steeper ground?

A. The area where contours are farthest apart
B. The area containing the largest printed elevation number
C. The area nearest the north arrow regardless of contour spacing
D. The area where adjacent contour lines are closest together

75. A profile drawing plots 100 horizontal feet per inch but only 10 vertical feet per inch. By what factor are vertical changes visually magnified relative to horizontal scale?

A. 1:10
B. 10:1
C. 100:1
D. 1:1

76. At a map scale of 1 inch = 40 ft, a plotting error of 0.02 inch corresponds to what ground distance?

A. 0.80 ft
B. 0.08 ft
C. 8.00 ft
D. 2.00 ft

77. A cross-section has elevation 602.4 ft at offset -20 ft and 606.4 ft at offset +20 ft. Assuming a straight line between them, what is the elevation at the centerline?

A. 602.4 ft

B. 606.4 ft
C. 608.4 ft
D. 604.4 ft

78. A mapped point plots at grid easting 3,200 ft and northing 7,450 ft. Which statement correctly interprets the coordinate pair?

A. The values by themselves state the point's ground elevation and contour interval
B. The easting is a slope distance and the northing is a vertical angle
C. The point is referenced by two perpendicular coordinate axes, with easting and northing locating its plan position
D. The coordinate pair is meaningful even if the map's coordinate reference and units are unknown

79. Why should a breakline be included along the top and toe of a steep engineered slope when building contours from survey points?

A. It automatically increases every measured elevation by one contour interval
B. It prevents triangulation from incorrectly smoothing across the sharp change in grade
C. It allows contours to cross one another without representing an overhang
D. It removes the need to survey points anywhere along the engineered slope

80. A benchmark symbol on a plan is labeled BM-4, EL 733.28. What does the elevation label primarily communicate?

A. The vertical reference value assigned to that benchmark within the stated project datum or elevation system
B. The horizontal distance from BM-4 to the project origin
C. The contour interval that must be used everywhere on the sheet
D. The magnetic declination applied to all bearings on the project

81. A proposed utility run extends from station 12+45.30 to station 15+88.70. What centerline distance separates the stations?

A. 243.40 ft
B. 343.40 ft
C. 443.40 ft
D. 34.34 ft

82. Starting from design EL 412.500 ft, follow a +0.012 tangent grade for 275 horizontal feet. What elevation should the curb reach at that distance?

A. 415.800 ft
B. 413.700 ft
C. 414.750 ft
D. 409.200 ft

83. A subgrade stake sits where measured ground is EL 518.26 ft and design subgrade is EL 516.84 ft. What vertical construction instruction follows from those elevations?

A. FILL 1.42 ft
B. CUT 0.71 ft
C. FILL 2.84 ft
D. CUT 1.42 ft

84. A straight alignment runs due north through E 8,200.00 ft. A layout point at N 4,500.00 ft is to be offset 18.00 ft to the right of increasing station. What are the offset-point coordinates?

A. N 4,518.00 ft, E 8,200.00 ft
B. N 4,500.00 ft, E 8,182.00 ft
C. N 4,500.00 ft, E 8,218.00 ft
D. N 4,482.00 ft, E 8,200.00 ft

85. A fill slope is specified as 2H:1V. If the catch point is 7.5 ft vertically below the hinge point, what horizontal distance separates them on the ideal slope?

A. 3.8 ft
B. 15.0 ft
C. 7.5 ft
D. 22.5 ft

86. A pavement section falls 2.0% from crown to gutter over a horizontal distance of 24.0 ft. What elevation drop should be staked?

A. 0.24 ft
B. 1.20 ft
C. 0.48 ft
D. 2.00 ft

87. Starting invert EL is 302.65 ft. Move 380 ft downstream on a constant grade of -0.006 ft/ft. Compute the required downstream invert.

A. 300.37 ft
B. 299.77 ft
C. 304.93 ft
D. 302.05 ft

88. Construction staking requires a chord spanning a 10° central-angle segment on a 500-ft radius circular curve. What chord length is needed?

A. 87.27 ft
B. 43.58 ft
C. 174.31 ft
D. 87.16 ft

89. For that 10° curve segment, what tangent deflection angle at the beginning of the segment sights the chord endpoint?

A. 5°00'
B. 10°00'
C. 2°30'
D. 20°00'

90. At x = 150 ft on a 400-ft parabolic curve, the PVC is EL 840.000 ft, g1 = -1.0%, and g2 = +2.0%. Determine the curve elevation to stake.

A. 838.500 ft
B. 839.344 ft
C. 840.844 ft
D. 842.250 ft

91. At a roadway section, the design hinge point is elevation 455.20 ft and existing ground at that offset is 451.70 ft. What condition exists at the hinge?

A. 3.50 ft of cut
B. 1.75 ft of fill
C. 6.90 ft of cut
D. 3.50 ft of fill

92. A rectangular building grid is 72.00 ft by 110.00 ft. What diagonal should be measured as an independent squareness check?

A. 182.00 ft
B. 91.00 ft
C. 131.47 ft
D. 131.00 ft

93. A wall line will be excavated away after initial layout. Why are reference offset stakes commonly set beyond the excavation limit?

A. They preserve a recoverable relationship to the design line after direct-line stakes are destroyed
B. They change the design line so excavation can proceed without coordinate control
C. They eliminate the need to record offset distances or station references
D. They are intended only as temporary elevation benchmarks and carry no horizontal information

94. A level setup has benchmark elevation 100.00 ft and backsight 4.25 ft. What rod reading would place a batter-board mark at elevation 103.60 ft?

A. 1.25 ft
B. 7.85 ft
C. 0.65 ft
D. 3.60 ft

95. Before relying on a machine-control model for finished grading, what survey check is most appropriate?

A. Assume the machine display is correct because the digital design file loaded successfully
B. Remove nearby physical control so operators cannot compare two coordinate sources
C. Accept finished grade solely from the visual smoothness of the constructed surface
D. Verify the model and machine position against independent project control and known design points

96. A roadway alignment contains a station equation 50+00 back = 49+60 ahead. What immediate effect does the equation have on station labels beyond that point?

A. The physical alignment shortens by 40 ft at the equation location
B. Station values decrease by 40 ft at the equation even though physical distance along the alignment remains continuous
C. All coordinates beyond the equation must be shifted 40 ft west
D. Vertical grades beyond the equation automatically change by 40 percent

97. A grade stake is marked 'STA 24+50, 12' RT, C 1.35 TO SG.' What does 'C 1.35 TO SG' communicate?

A. Fill 1.35 ft from subgrade to finished pavement regardless of stake elevation
B. Move the stake 1.35 ft toward centerline before using the station reference
C. Rotate the stake 1.35 degrees to align it with the roadway tangent
D. Cut 1.35 ft from the reference mark to the specified subgrade surface

98. Two anchor-bolt layout points have coordinates N 2,200.00 ft, E 1,800.00 ft and N 2,284.00 ft, E 1,936.00 ft. What distance separates them?

A. 159.85 ft
B. 84.00 ft
C. 136.00 ft
D. 220.00 ft

99. An installed pipe has upstream invert elevation 501.25 ft and downstream invert elevation 499.09 ft over 240 ft. What as-built slope is indicated?

A. +0.90%
B. -2.16%
C. -0.90%
D. -0.24%

100. A completed concrete column is surveyed 0.18 ft east and 0.04 ft north of its design center. What should an as-built report do?

A. Move the design center in the survey file so the column appears to be on position
B. Report the measured positional differences relative to the stated design and control reference without silently shifting the design coordinates
C. Round both offsets to zero because they are less than one foot
D. Change the project datum until the column coordinate matches the planned value

Practice Exam 8: Answer Key and Explanations

1. A — Primary control should survive the work it supports. Stable, redundant monuments outside grading and settlement influence provide a recoverable reference if local working points are lost. Temporary pavement, unrelated trade systems, and machine-only references weaken continuity. Working control can be densified near construction, but it should remain traceable to the same durable project framework.

2. C — Elevations cannot be merged safely until their reference systems are related. A verified common benchmark, transfer observation, or other defensible tie establishes the offset or transformation between systems. Averaging unrelated elevations creates a hybrid datum, relabeling does not change numeric meaning, and using two untied systems can create systematic vertical conflicts in design and staking.

3. D — Detecting small movement requires uncertainty appreciably below the movement threshold. Display resolution alone does not establish field accuracy, and long range does not guarantee sufficient precision. Repeated and independent observations help separate actual displacement from random variation and setup error. The planned method should therefore control the full measurement process, not merely the number of digits displayed.

4. B — Remote sensing can provide efficient coverage, but vegetation and occlusion may prevent reliable ground classification in critical areas. Targeted ground observations and breaklines improve definition of channels, ridges, walls, and abrupt grade changes. Sparse roadway shots or an old map may not satisfy project accuracy, while omitting breaklines can create a visually smooth but geometrically false surface.

5. C — Reconnaissance should identify the physical conditions that govern how observations can actually be made. Satellite obstruction affects GNSS, while intervisibility affects total-station work; access, safety, and monument stability affect both. Drawing preferences and sheet counts do not determine measurement feasibility. A control scheme should respond to site conditions and include enough redundancy for independent checking.

6. B — A route survey supports linear engineering design by establishing control, existing features, terrain, profile information, and alignment-related data along a corridor. It is not automatically a boundary retracement of adjoining parcels, and temporary stakes do not replace a coherent control framework. Photographs can supplement the work, but measured horizontal and vertical information remains central to route design.

7. A — An assumed system can be perfectly usable for local engineering work if its origin, orientation, units, and vertical reference are clearly documented. Calling it state plane would imply a geodetic relationship that has not been established. Changing origins destroys continuity, while omitting the system definition makes later recovery, checking, and integration unnecessarily difficult.

8. D — GIS can efficiently organize and display utility information, but its positional reliability depends on the source data and metadata. A line shown on a map may represent record information rather than a surveyed location. Critical conflicts should therefore be verified by field methods appropriate to the risk. Blind acceptance and complete rejection are both poor uses of available information.

9. B — Redundancy allows the network to be checked and reconstructed when an individual point is lost or moves. Multiple recoverable points tied by independent observations provide evidence of consistency. A single monument creates a failure point, while unrelated coordinate systems complicate comparison. Requiring every setup on one mark may increase exposure to disturbance rather than improve network strength.

10. D — Precision describes repeatability, while accuracy describes agreement with the true or accepted value. The readings cluster tightly, so they are precise, but the common 0.050-ft systematic bias makes them inaccurate. Repetition alone cannot reveal or remove every systematic error. A control check, calibration, or correct prism setting is needed to evaluate accuracy as well as precision.

11. C — A difficult vertical transfer should be planned to reduce systematic effects and include redundancy. Reciprocal or otherwise suitable precise observations can mitigate unequal sight and atmospheric influences, and closure to independent control provides a check. A single extreme sight, water-surface assumption, or arbitrary new elevation lacks the evidence needed for reliable project control.

12. A — Deformation is determined relative to a reference assumed to remain stable. Monuments on the moving structure, within the likely influence zone, or on temporary work cannot separate true wall movement from reference movement. Stable external monuments provide the baseline needed to interpret repeated observations and should themselves be checked for consistency during the monitoring program.

13. A — Potential conflicts depend on the actual horizontal and vertical relationship between proposed work and existing facilities. Record maps are useful starting points but may not provide construction-grade positions or current conditions. Critical crossings should be verified with appropriate field investigation. Changing a datum cannot solve a physical conflict, and postponing verification can transfer an avoidable risk into construction.

14. D — Breaklines tell a terrain model that certain linear features control surface continuity and slope. Without them, triangulation may connect points across a curb, ditch, wall, or ridge in a way that smooths over an actual grade break. Breaklines do not replace elevation observations, create datum transformations, or merely add graphic labels; they preserve measured terrain structure.

15. C — Dense urban obstruction can degrade GNSS visibility and increase multipath, while good terrestrial intervisibility favors total-station observations. A practical plan can use GNSS where sky view is adequate and transfer control terrestrially into obstructed areas. Handheld coordinates and scaled plan dimensions generally do not provide the checked precision expected for project control.

16. B — A known check can reveal an incorrect occupation, orientation, prism constant, instrument setting, or other systematic problem before many points are collected. It does not make later measurements exact, replace maintenance and calibration, or establish compatibility with unrelated datums. Its value is early detection: a small controlled test can prevent a large batch of corrupted production data.

17. D — Coordinate values are only meaningful within their defined system. Integrating local and geodetic data requires a documented transformation or common control relationship, including units, datum, projection, orientation, and any scale effects that matter. Renaming columns or visually shifting files can hide discrepancies and produce coordinates that appear plausible without being reproducible or geometrically consistent.

18. C — A temporary benchmark should be convenient but stable for the period it must serve. Excavation, vibration, settlement, and traffic can disturb otherwise accessible marks. A durable object outside those influences, described so another crew can recover it, provides a more reliable vertical reference. Proximity alone is not useful if the mark is likely to move or disappear.

19. A — Traverse strength improves when geometry avoids extremely weak angles and highly unbalanced line lengths, and when the work closes on itself or known control. Nearly collinear stations and one dominant long side amplify the effect of small angular errors. An open traverse without an independent check provides little evidence of accumulated positional error.

20. B — A rotated construction grid can make layout simpler, but the relationship to project control must remain explicit. The origin, rotation angle, units, and any scale or translation should be documented so coordinates can be transformed and checked. A CAD file alone does not preserve survey intent, and falsely calling rotated grid north true north creates directional ambiguity.

21. D — A design topographic survey measures existing features and terrain so engineers can analyze and design proposed work. Construction staking does the reverse relationship: it takes approved design geometry and marks positions or grades in the field. The same instruments and control may support both, but their purposes, deliverables, and checks differ substantially.

22. A — Offset staking protects layout marks from construction while preserving a geometric relationship to the design feature. The offset direction, distance, station or point identity, elevation information when relevant, and control reference should be recorded. Random or unrecorded offsets are difficult to reproduce, and relying on unchecked existing features can introduce unrecognized positional error.

23. C — Images can capture extensive detail, but the resulting model must still be related to the project coordinate and elevation system. Ground control or a verified direct-georeferencing solution provides that relationship and offers checkpoints for accuracy assessment. It does not eliminate occlusion, vegetation problems, or the need to evaluate image geometry and acquisition quality.

24. B — Survey methods should be selected to satisfy the required accuracy, not merely to produce coordinates. If expected uncertainty is too large, the plan may need stronger control, better equipment, shorter sights, repeated observations, improved procedures, or more favorable conditions. Extra digits and attractive plotting do not create accuracy that the measurement process cannot support.

25. D — Clear acceptance criteria make the survey reproducible and reviewable. The plan should identify deliverables, datum and control references, accuracy expectations, closure or check requirements, and procedures for discrepancies. Deferring these decisions until after fieldwork risks collecting insufficient data or using incompatible methods. Fewer observations do not improve quality simply by avoiding opportunities to detect disagreement.

26. A — For a zenith angle z, horizontal distance is S sin(z). Using 684.25 sin(93°20') gives 683.09 ft. Because the sight is only a few degrees below horizontal, the horizontal distance should be slightly less than the slope distance. The vertical component would use cosine of the zenith angle and carry a negative sign here.

27. B — Height of instrument is 412.680 + 5.224 = 417.904 ft. Subtract the 7.931-ft foresight to obtain the turning-point elevation: 417.904 - 7.931 = 409.973 ft. Adding the foresight or reversing backsight and foresight signs violates the standard differential-leveling relationship. The point elevation should also fit the expected direction of grade.

28. C — Vertical component equals slope distance times sine of the elevation angle. Thus 455.60 sin(6°35') = 52.23 ft. The positive sign indicates the target is above the instrument axis. Cosine produces the horizontal component, while using the angular value itself as a linear difference does not represent the sight-line geometry. The observation should be recorded with enough setup information for an.

29. A — A foresight rod reading is subtracted from height of instrument. Therefore 633.742 - 4.386 = 629.356 ft. Adding the rod reading would place the point above the line of sight, contrary to the leveling convention. The result assumes the HI was established correctly from a known backsight and the rod was on the intended point.

30. B — An azimuth between 180° and 270° lies in the southwest quadrant. Subtract 180° from 214°18' to obtain 34°18', giving S 34°18' W. The other bearings place the line in the wrong quadrant or use the complement rather than the correct angle from south. Direction conventions should be converted before field staking begins.

31. D — Because the degree and minute values match, average the seconds: (42 + 54)/2 = 48 seconds. The mean angle is therefore 47°16'48". Direct and reverse observations help reduce certain instrumental effects and provide an immediate consistency check. Simply choosing one reading discards useful redundancy, while adding the seconds rather than averaging produces an incorrect direction.

32. C — Temperature correction is $\alpha(T - T0)L$. Substituting 0.00000645(92 - 68)(100.00) gives +0.0155 ft. The warmer tape is longer than its standard length, so the measured reading is slightly short relative to true distance and receives a positive correction. The much larger alternatives misplace the decimal or units. The observation should be recorded with enough setup information for an independent check.

33. D — Parts per million is a scale term proportional to measured distance. Compute 2,460 x 3.0 / 1,000,000 = 0.0074 ft. The units remain feet because ppm is dimensionless. Constant instrument error, centering uncertainty, and atmospheric corrections are separate components and would need independent consideration if the problem supplied them. The observation should be recorded with enough setup information for an.

34. B — The prism constant accounts for the optical offset of the reflector system. If the instrument setting does not match the actual prism, reflector distances inherit a systematic bias. The effect is not random angular scatter, does not redefine the project datum, and can matter on short precision layout lines as well as longer measurements because it is essentially an additive.

35. A — A float RTK solution generally has unresolved ambiguities and higher, less predictable uncertainty than a fixed solution. Critical control should therefore not be accepted merely because coordinates are displayed. Improve observation conditions, reinitialize, occupy longer if appropriate, or use a checked terrestrial method. Independent verification is especially important when the point will control subsequent construction layout.

36. C — The instrument-axis elevation is 525.360 + 5.10 = 530.460 ft. The sight rises by 312.40 sin(4°10') and reaches the prism center; subtract the 6.00-ft prism height to obtain 547.158 ft at the ground point. Using cosine substitutes horizontal distance, while omitting HI or prism height changes the referenced elevation. The observation should be recorded with enough setup information for an.

37. A — The observed closing elevation is 288.614 + 36.782 - 35.945 = 289.451 ft. Misclosure equals observed minus known: 289.451 - 289.468 = -0.017 ft. The BS-FS sum is the net elevation change, not the closure error. The sign indicates whether the observed closure ended above or below the accepted benchmark elevation.

38. D — Coordinate differences are ΔN = +262 ft and ΔE = -217 ft. Horizontal distance is sqrt(262^2 + 217^2) = 340.20 ft. The component magnitudes describe movement along the coordinate axes, while their sum is only a rectangular path. The signs determine quadrant but do not change the straight-line distance magnitude.

39. B — Percent grade is 100 times rise divided by horizontal run, which equals 100 tan(theta). Using theta = 2°45' gives 100 tan(2.75°) = 4.80%. The angle in degrees is not numerically the same as percent grade. Sine would relate rise to slope distance rather than horizontal run. The observation should be recorded with enough setup information for an independent check, because.

40. C — An immediate check to known control tests occupation coordinates, orientation, centering, prism settings, and point identification before errors can propagate through many observations. Software acceptance confirms only that inputs are internally usable. Delayed checking increases rework, while changing the coordinate system to make a detail point fit hides rather than diagnoses the actual problem.

41. A — Latitude, or change in northing, is distance times cosine of azimuth. Thus 538.70 cos(146°20') = -448.35 ft. An azimuth in the southeast quadrant must produce a negative northing change and positive easting change. The sine term gives departure, and changing the sign would place the endpoint in the wrong quadrant.

42. B — Departure, or change in easting, is distance times sine of azimuth. Therefore 538.70 sin(146°20') = +298.63 ft. The positive sign is consistent with the southeast quadrant. The cosine term gives the northing component, which is negative for this azimuth. Checking signs against the quadrant is an efficient defense against swapped or reversed components.

43. D — From the previous component relations, ΔN = -448.35 ft and ΔE = +298.63 ft. Add those signed components to the starting coordinates: N = 12,000.00 + (-448.35) = 11551.65 ft and E = 8,450.00 + 298.63 = 8748.63 ft. Swapping or reversing components places the endpoint in a different quadrant.

44. C — Linear closure is the vector magnitude of the coordinate residuals: $\text{sqrt}(0.18^2 + (-0.24)^2) = 0.30$ ft. Adding signed components gives -0.06 ft, which is not a vector magnitude; adding absolute components gives 0.42 ft. Closure direction and magnitude should be evaluated separately before any adjustment is distributed. A final reasonableness check of units, sign, quadrant, and geometry helps prevent a.

45. C — Relative precision compares total traverse length with linear closure error. Divide 4,850 ft by 0.30 ft to obtain approximately 16,167. The result is expressed as about 1:16,167. Using the perimeter alone or dividing by unrelated factors does not describe closure quality. The applicable project requirement should then be compared with this computed precision.

46. D — Bowditch distributes coordinate misclosure in proportion to course length and with opposite sign to the misclosure. The course receives -0.25(720/3,600) = -0.050 ft in northing. A positive correction would worsen the closure, while assigning the entire 0.25-ft residual to one course would not follow proportional adjustment. A final reasonableness check of units, sign, quadrant, and geometry helps prevent a numerically.

47. A — When the stated angle is measured clockwise from the forward extension of the incoming direction as defined here, add it to the current azimuth: 72°40' + 113°25' = 186°05'. The result lies just west of south. Direction problems require close attention to whether the given angle is a right angle, deflection, interior angle, or backsight-based angle.

48. B — A northwest bearing is measured westward from north. Convert it to clockwise azimuth by subtracting the bearing angle from 360°: 360°00' - 27°35' = 332°25'. An azimuth of 27°35' lies northeast, 152°25' lies southeast, and 207°35' lies southwest. Quadrant checking quickly eliminates those alternatives. A final reasonableness check of units, sign, quadrant, and geometry helps prevent a numerically neat result.

49. B — Using the coordinate or shoelace area formula, sum each x times the next y, subtract each next x times the current y, take the absolute value, and divide by two. For the five listed vertices the result is 35,525.0 square feet. Reversing point order changes only the sign before the absolute value, not the area magnitude.

50. A — For a simple circular curve, tangent length $T = R \tan(\Delta/2)$. Substituting R = 650 ft and $\Delta/2$ = 22° gives T = 262.62 ft. Curve length uses $\pi R\Delta/180$, long chord uses $2R \sin(\Delta/2)$, and external distance uses $R(\sec(\Delta/2) - 1)$. Identifying the requested curve element is essential. A final reasonableness check of units, sign, quadrant, and geometry helps prevent.

51. C — Arc length of a simple circular curve is $L = \pi R\Delta/180$ when Δ is in degrees. With R = 650 ft and $\Delta = 44°$, L = 499.16 ft. Tangent length, long chord, and external distance use different trigonometric relationships. The arc length follows the curved centerline rather than the straight chord between PC and PT.

52. D — The long chord spans the curve endpoints directly and equals $2R \sin(\Delta/2)$. For R = 650 ft and $\Delta = 44°$, $2(650)\sin(22°) = 486.99$ ft. It must be shorter than the arc length for a nonzero curve. Tangent and external distances describe different parts of the same circular geometry. A final reasonableness check of units, sign, quadrant, and geometry helps.

53. B — External distance is $E = R(\sec(\Delta/2) - 1)$. Substituting R = 650 ft and $\Delta/2 = 22°$ gives E = 51.05 ft. The value is much smaller than tangent, long chord, or arc length because it measures the maximum radial offset between the PI direction and the circular curve near its midpoint.

54. A — PT station equals PC station plus arc length, not tangent length or long chord. The curve length is 499.16 ft, so 12,540.00 + 499.16 = 13039.16 ft, written as station 130+39.16. Stationing follows accumulated centerline distance even though the physical straight-line distance from PC to PT is shorter. A final reasonableness check of units, sign, quadrant, and geometry helps prevent.

55. D — At the midpoint of the arc, the central angle from PC to that point is one-half the total curve angle, or 22°. The tangent-to-chord deflection equals one-half the intercepted central angle, so the required deflection is 11°. Using 22° confuses the central angle with the deflection, while 44° is the full curve angle.

56. C — Use the parabolic vertical-curve equation $E = E_{PVC} + g_1 x + (g_2 - g_1)x^2/(2L)$, with grades as decimals. At x = 300 ft, $E = 710.000 + 0.018(300) + (-0.030)(300^2)/(1{,}200) = 713.150$ ft. Using only the entering tangent ignores curvature; using percent values directly creates a scale error. A final reasonableness check of units, sign, quadrant, and geometry helps.

57. A — Rate of grade change for a parabolic vertical curve is A/L, where $A = g_2 - g_1$. Here A = -0.012 - 0.018 = -0.030, and -0.030/600 = -0.0000500 per foot. The -0.030 value is the total algebraic grade difference, not the per-foot rate. The negative sign indicates decreasing grade.

58. D — The curve grade at distance x is $g(x) = g_1 + (A/L)x$. At the high point the grade is zero, so $x = -g_1 L/A = -0.018(600)/(-0.030) = 360.0$ ft from the PVC. The high point is not necessarily at the midpoint unless entering and leaving grade magnitudes are equal.

59. B — Horizontal distance and vertical difference form perpendicular components, so slope distance is $\sqrt{500^2 + 36^2} = 501.29$ ft. Adding the components gives a path length rather than the straight line. A slope distance must be slightly greater than the horizontal distance whenever the vertical difference is nonzero, providing a useful magnitude check.

60. C — Grade percent equals elevation change divided by horizontal run times 100. The change is 318.40 - 326.90 = -8.50 ft, so grade = (-8.50/425)(100) = -2.00%. The negative sign indicates falling grade in the direction of increasing station. Using the elevation difference alone as a percentage ignores the run distance.

61. B — The profile rises 8.00 ft over 400 ft, or 0.020 ft per foot. Station 11+75 is 175 ft beyond station 10+00, so the rise is 0.020(175) = 3.50 ft. Adding that to 250.00 gives 253.50 ft. Linear interpolation is appropriate because the problem states a straight grade between endpoints. A final reasonableness check of units, sign, quadrant, and geometry helps.

62. D — A proportional correction at 3.0 miles is the opposite of the total misclosure times the distance fraction: -0.024(3/8) = -0.009 ft. The correction accumulates from zero at the starting control toward the full opposite misclosure at closure. Reversing the sign would increase the residual rather than remove it. A final reasonableness check of units, sign, quadrant, and geometry helps prevent.

63. A — With equal weights, the arithmetic mean is (301.42 + 301.38 + 301.40)/3 = 301.40 ft. Selecting the minimum or maximum discards valid observations, while the sum is not a representative distance. The small spread indicates good repeatability, but a separate check against control or calibration is still needed to assess accuracy.

64. C — Coordinate changes are ΔN = d cos(azimuth) and ΔE = d sin(azimuth). At 305°, the line is northwest, so northing must increase and easting must decrease. The calculations give ΔN = +240.90 ft and ΔE = -344.04 ft. Quadrant logic is a useful check against swapped or incorrectly signed components.

65. A — Every point on the north-south line has easting 7,250.00 ft, and every point on the east-west line has northing 3,880.00 ft. Their intersection must satisfy both conditions simultaneously, giving N 3,880.00 ft, E 7,250.00 ft. Swapping northing and easting is a common clerical error when reading rectangular-coordinate information. A final reasonableness check of units, sign, quadrant, and geometry helps prevent.

66. D — Trapezoid area equals the average of the parallel sides times their perpendicular separation: ((140 + 210)/2)(95) = 16,625 square feet. Multiplying the side sum directly by height doubles the correct area. Using only one base ignores the taper represented by the second parallel side. A final reasonableness check of units, sign, quadrant, and geometry helps prevent a numerically neat result.

67. C — Apply the combined factor by multiplying the ground distance: 1,250.000(0.999920) = 1249.900 ft. Because the factor is slightly less than one, the grid distance must be slightly shorter than the ground distance. Adding the factor or interpreting 0.999920 as a direct number of feet would give physically inconsistent results. A final reasonableness check of units, sign, quadrant, and geometry helps.

68. B — For an eastbound alignment, left is north and right is south. The feature northing is 27.50 ft less than the alignment northing, so it lies 27.50 ft south, or to the right. With left defined positive, the signed offset is therefore -27.50 ft. The large coordinate values are absolute positions, not offset magnitudes.

69. C — One acre contains 43,560 square feet. Dividing 108,900 by 43,560 gives approximately 2.50 acres. Multiplying by 43,560 would convert in the opposite direction. A quick reasonableness check also helps: two acres equal 87,120 square feet, so the answer should be somewhat greater than two acres but well below four. A final reasonableness check of units, sign, quadrant, and geometry helps.

70. B — Average-end-area volume is ((A1 + A2)/2)L. The average area is 800 sq ft, so volume is 800(100) = 80,000 cubic feet. Divide by 27 to convert to cubic yards, giving 2,963.0 cu yd. Using one end area alone or failing to convert cubic feet would produce a different quantity. A final reasonableness check of units, sign, quadrant, and geometry helps.

71. A — At a scale of 1 inch = 50 ft, multiply the measured plan length by 50: 6.35(50) = 317.5 ft. Dividing would convert in the wrong direction, and moving the decimal without using the stated scale has no basis. Scale calculations should use the plotted distance only when the drawing has not been distorted by reproduction.

72. D — Scale is ground distance divided by plotted length: 420 ft / 7.00 in = 60 ft per inch. Therefore the scale is 1 inch = 60 ft. A scale of 1 inch = 420 ft would apply only if the entire 420-ft distance measured one inch on the sheet, not seven inches.

73. C — The total rise is 8 ft over 64 ft. The 520-ft contour is 4 ft above the lower point, one-half of the total elevation difference. With the stated uniform slope, its plan position is therefore one-half of 64 ft, or 32 ft from the 516-ft point. Irregular terrain would require additional observations.

74. D — Contour spacing reflects horizontal distance required for a fixed vertical interval. Closely spaced contours mean the elevation changes rapidly over a short horizontal distance, indicating steeper terrain. Widely spaced contours indicate gentler slope. The magnitude of the contour label and the map's north-arrow location do not independently determine steepness. The mapped result should remain consistent with the stated scale, contour.

75. B — Vertical exaggeration is the horizontal scale denominator divided by the vertical scale denominator when both are expressed in the same ground units per inch. Here 100 ft/in divided by 10 ft/in equals 10, so vertical features appear ten times more pronounced than with equal scales. This affects visual interpretation but not the underlying surveyed elevations.

76. A — Ground effect equals plotting error times scale: 0.02 in x 40 ft/in = 0.80 ft. This illustrates how seemingly small graphic differences can represent meaningful ground distances. The calculation addresses only the scale conversion; it does not by itself establish whether the source survey or finished map satisfies a particular accuracy requirement.

77. D — The centerline lies halfway between the -20-ft and +20-ft offsets. With a straight line between endpoints, the elevation is the average: (602.4 + 606.4)/2 = 604.4 ft. Choosing either endpoint ignores interpolation, while 608.4 ft extrapolates above both known values even though the center lies between them. The mapped result should remain consistent with the stated scale, contour logic, control.

78. C — Rectangular coordinates locate a plan position by distances or coordinate values along perpendicular easting and northing axes. They do not inherently state elevation, slope distance, or angle. Their numeric values are useful only when the coordinate system, units, origin, orientation, and any applicable datum or projection information are known or otherwise defined on the mapping product.

79. B — A breakline constrains the surface model along a known linear change in slope. Without it, triangles may connect points across the top or toe and create contours that cut through the intended grade break. Breaklines do not change measured elevations, eliminate the need for observations, or permit ordinary terrain contours to cross each other arbitrarily.

80. A — A benchmark is a vertical-control reference, and the listed elevation identifies its value in the project's stated elevation system or datum. The label does not give horizontal distance, contour interval, or magnetic declination. For reliable use, the plan or survey records should also make the benchmark description and vertical reference clear enough for field recovery.

81. B — Convert stationing to feet: 12+45.30 = 1,245.30 ft and 15+88.70 = 1,588.70 ft. Their difference is 343.40 ft. The plus sign in station notation separates hundreds of feet; it is not an arithmetic operator. Correctly converting station labels before subtraction prevents common construction layout mistakes. Construction notes should state the reference surface, offset direction, station, and sign convention clearly enough.

82. A — A +1.20% grade means a rise of 0.012 ft per horizontal foot. Over 275 ft, rise = 0.012(275) = 3.300 ft. Add that to 412.500 to obtain 415.800 ft. A positive grade increases elevation in the direction of stationing; subtracting would reverse the intended slope. Construction notes should state the reference surface, offset direction, station, and sign convention clearly enough.

83. D — Existing ground is higher than proposed subgrade, so material must be removed. The difference is 518.26 - 516.84 = 1.42 ft, giving CUT 1.42 ft. Calling it fill reverses the construction action. A stake note should also identify the referenced design surface so crews do not confuse subgrade with finished grade.

84. C — For a northbound alignment, right is east. An 18.00-ft right offset therefore increases easting from 8,200.00 to 8,218.00 ft while northing at the station remains 4,500.00 ft. Changing northing would move along the alignment rather than perpendicular to it, and decreasing easting would place the point on the left side.

85. B — A 2H:1V slope requires 2 horizontal units for each 1 vertical unit. For a 7.5-ft vertical difference, horizontal run = 2(7.5) = 15.0 ft. Using 7.5 ft would describe a 1:1 slope, while dividing by two would make the slope steeper. Field catch points still depend on actual ground intersection.

86. C — A 2.0% cross slope is 0.020 ft of vertical change per horizontal foot. Over 24.0 ft, drop = 0.020(24.0) = 0.48 ft. The percentage is not the drop in feet. The stake should also make clear which direction falls and whether the referenced elevation is finished surface or another construction layer.

87. A — A -0.60% grade equals -0.006 ft per horizontal foot. Over 380 ft the elevation change is -0.006(380) = -2.28 ft. Add that change to 302.65 to obtain 300.37 ft. The negative sign is important because the invert falls in the direction of increasing station rather than rises. Construction notes should state the reference surface, offset direction, station, and sign convention.

88. D — A chord subtending central angle theta has length C = 2R sin(theta/2). For R = 500 ft and theta = 10°, C = 1,000 sin(5°) = 87.16 ft. Arc length for the same segment is slightly longer. Using half the chord or doubling it would not match the circle geometry.

89. A — The tangent-chord angle equals one-half the central angle intercepted by the chord. A 10° central segment therefore requires a 5° deflection from the tangent to the chord endpoint. Using the full 10° confuses central angle with deflection, while 2°30' halves the angle twice. This relationship is fundamental to traditional curve staking.

90. B — Use $E = E_{PVC} + g1\ x + (g2 - g1)x^2/(2L)$. Here $E = 840.000 - 0.010(150) + 0.030(150^2)/(800) = 839.344$ ft. Using only the entering tangent gives 838.500 ft and ignores curvature. Grades must be entered as decimals, not whole percentage numbers. Construction notes should state the reference surface, offset direction, station, and sign convention clearly enough that another.

91. D — The design hinge elevation is higher than existing ground by 455.20 - 451.70 = 3.50 ft, so fill is required at that location. A cut would apply if existing ground were above design. The hinge difference is useful for projecting a side slope, but the actual catch point must be found where the designed slope intersects existing terrain.

92. C — For a rectangle, the diagonal follows the Pythagorean relationship: $\mathrm{sqrt}(72^2 + 110^2) = 131.47$ ft. Matching both diagonals is a useful geometric check when side lengths are correct. Adding the sides gives perimeter-related distance, not a diagonal. A correct diagonal does not replace checking the grid against project control. Construction notes should state the reference surface, offset direction, station, and.

93. A — Offset stakes allow the intended line or point to be reconstructed after direct stakes are removed by excavation, traffic, or formwork. Their value depends on a recorded distance and direction to the design feature and a clear reference to project control. They do not change design geometry and should not be treated as undocumented or purely vertical marks.

94. C — Height of instrument is 100.00 + 4.25 = 104.25 ft. The rod reading corresponding to elevation 103.60 ft is HI - elevation = 104.25 - 103.60 = 0.65 ft. Adding the target elevation to HI or using the benchmark difference alone does not follow the leveling relationship used to transfer grade.

95. D — Machine control can efficiently guide construction, but its coordinates depend on the correct model, localization, antenna setup, calibration, and project reference. Independent checks to known control and design points can reveal a systematic shift or wrong file before large areas are built. A successful file load or visually smooth surface does not prove positional correctness.

96. B — A station equation changes the numerical stationing reference, not the physical location or geometry of the alignment. Here, the ahead station is 40 ft less than the back station at the same point, so labels beyond the equation reflect that jump. Coordinates, grades, and actual measured distances do not automatically shift because of the stationing convention.

97. D — The notation identifies a cut quantity to the specified design surface, here subgrade. It tells the construction crew the vertical relationship from the stake's referenced mark to that surface, while the station and offset identify horizontal location. Stake conventions can vary by project, so the surface abbreviation and sign convention should be defined in the staking notes.

98. A — The coordinate differences are $\Delta N = 84$ ft and $\Delta E = 136$ ft. The straight distance is $\text{sqrt}(84^2 + 136^2) = 159.85$ ft. Using either component alone does not represent the diagonal bolt spacing, while adding components gives a rectangular path. This distance can serve as an independent check on coordinate-based layout.

99. C — Slope percent in the downstream direction is $(499.09 - 501.25)/240 \times 100 = -0.90\%$. The negative sign indicates the pipe falls downstream. The 2.16-ft elevation difference is not itself a percentage, and dividing by 100 instead of multiplying by 100 would understate the slope substantially. Construction notes should state the reference surface, offset direction, station, and sign convention clearly enough.

100. B — An as-built survey documents what was constructed relative to the controlling design reference. The measured east and north differences should be reported clearly so the responsible project team can evaluate tolerance or corrective action. Altering design coordinates, rounding meaningful offsets away, or changing the datum would conceal the actual relationship rather than document it.