NSPS

SURVEY TECHNICIAN CERTIFICATION PROGRAM

LEVEL 2
SAMPLE EXAMINATION QUESTIONS

NATIONAL SOCIETY OF PROFESSIONAL SURVEYORS

February 2024

This booklet has been prepared to provide an example of what an actual Certified Survey Technician (CST) Examination might be like. Using this as your only study guide is not recommended.

This examination is approximately 50% of an exam. The work element order is the same as in the full examination with approximately one half the number of questions (this will vary due to difference in the number of questions in some work element categories in the Construction versus the Office specialty exams.)

These are not exactly questions from past exams, but do reflect the complexity and makeup of actual exam questions.

Additional information about the CST program and exam availability can be obtained at:

- www.cstnsps.com
- (240) 439-4615
- NSPS CST Program
  21 Byte Court, Suite H
  Frederick, MD 21702

A complete list of recommended books can be found on the CST website under the Applicants section. The recommended books mention are not particularly endorsed for any specific reason nor are they endorsed by the NSPS or other Survey related Association or Society. They represent a cross section of how, where, and what may be utilized as a resource to derive methods of study in preparation for the CST Exams.

At minimum an examinee should bring:

1). A Fundamental Surveying Text (with Unit Conversion Charts)
2). A First Aid & Safety Manual
3). Definitions of Surveying and Associated Terms (NSPS)

LEVEL 2 QUALIFICATIONS

FIELD: 1.5 years of surveying experience OFFICE: 1.5 years of surveying experience

OR 65 transcripted semester hours, or quarterly equivalent, of which 18 semester hours are surveying/engineering related plus six months of work experience or any combination of education and work experience equivalent to 1.5 years.

LEVEL 2

SURVEY TECHNICIAN CERTIFICATION

POSITION DESCRIPTION, WORK ELEMENTS AND NUMBER OF QUESTIONS

This is an open book exam.

POSITION DESCRIPTION

In addition to the Level I knowledge and skills, **Level II Technicians** are required to demonstrate more detailed knowledge of survey computations, types of surveys and field operations. The individual in this position is familiar with comprehensive field note taking, plan reading and preparation. The field track technician possesses a detailed working knowledge and application of standard field equipment. The office track technician possesses a detailed working knowledge and application of related computer hardware and software. The technician has a basic knowledge of the principles of the profession. Work Elements further describes the requirements related to this position.

WORK ELEMENTS

Test problems will be taken from the following work elements:
(The number of questions from each Work Element (F = Field Exam) (O = Office Exam)

1) *Survey Types and History* (F=7; O=10)
Knowledge of the different types of surveying and the basic differences between them.
Knowledge of the historical development of survey procedures and practices

2) *Field Equipment & Operations* (F=56; O=25)
Knowledge of the principles of performing basic surveys: leveling, traversing, triangulation, trilateration, public land surveys, metes and bounds surveys, construction surveys, photo control surveys, and GPS surveys.
Knowledge of the operation, checking, and basic field adjustments on transits, theodolites, total stations, robotic total stations, data collectors, levels, compass, tribrachs, tripods, and GPS equipment. Some knowledge on newer technologies such as Scanning/LIDAR, UAV, Mobile Mapping, GIS and BIM is expected. Some historical knowledge is also required.
Know how to keep neat and orderly field notes and data collectors files for standard surveying operations: leveling, traversing, topographic mapping, layout, as-built surveys, boundary surveys, profile and cross-section surveys.
Under the supervision of a party chief, be able to coordinate field work for a variety of standard types of surveys. Know basic sources of measurement errors. Know principles of staking and stake markings. Know procedures for GPS surveys.

3) *Survey Control* (F=7; O=7)
Know how to interpret control point records and data sheets, as well as create and locate points in the field.

4) *Survey Computations* (F=30; O=40)
Knowledge of trigonometry, geometry, algebra, coordinate geometry, and basic surveying computations. A familiarity with hand-held calculators and computers is important. With either a hand-held calculator

or computer/data collector software, be able to enter field data and produce positional information (i.e. leveling, traversing, stadia, topographic mapping and construction stakeout). Demonstrate lot, area, and intersection (bearing-bearing, distance-distance, bearing-distance) computations. Knowledge of the reduction and checking of field notes for determination of positions and elevations as well as the adjustment of that data. Have an elementary comprehension of computer operating systems and GIS.

5) *Office Operations., Plan Reading and Preparation* (F=10; O=31)
Knowledge and understanding of the basic plan reading and preparation (i.e. site plans, boundary plans, highway plans, profile and cross sections, horizontal and vertical curves, pipeline plans, foundation plans, and developing existing and finished contours). A basic knowledge of the terminology and principles of drafting, including computer-aided drafting (CAD). Some knowledge of computer operating systems and hardware peripherals.

6) *First Aid & Safety* (F=10; O=10)
Basic knowledge of treatment practices for a variety of medical emergencies. Knowledge of traffic control and safety procedures for a variety of surveying and construction operations, including Occupational Safety and Health Administration (OSHA) standards.

7) *Principles of the Profession* (F=10; O=7)
Knowledge of surveying ethics and technical standards. Show responsibility in the profession (i.e. attire, honesty, respect for personal property), awareness of related professional association.

TOTAL NUMBER OF QUESTIONS = 130, TIME = 4 hours

CST LEVEL II SAMPLE TEST
and Answer Guide
JANUARY 2023

Types of Surveys (4)

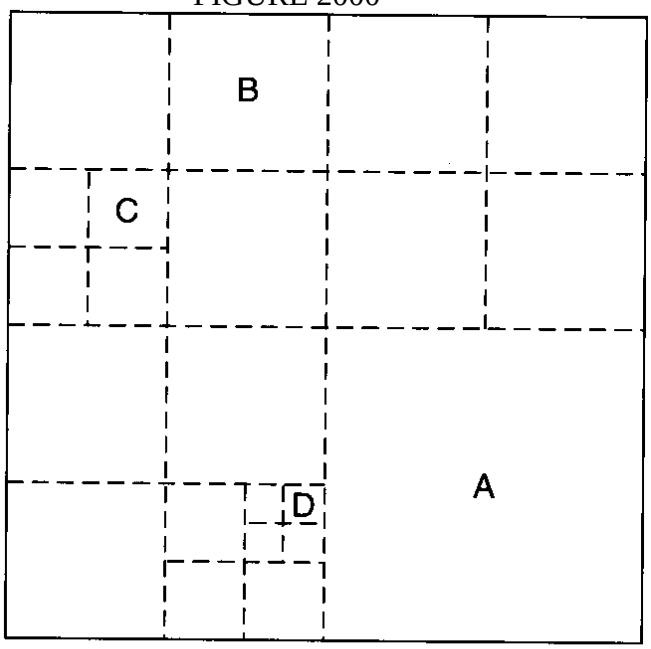
1. What was one of the first developments (in the 1960's) that lead to the growth and development of GIS?

    1. GPS being made available to everyone
    2. The advent of the computer
    3. Commercial satellites
    4. College courses

2. In the figure 2000 below, parcel C would be described as:

    1. NE ¼, NW ¼, Sec 15
    2. NE ¼, SW ¼, NW ¼, Sec 15
    3. NE ¼, NE ¼, SE ¼, SW ¼, Sec 15
    4. NE ¼, SE ¼, NW ¼,Sec 15

FIGURE 2000



3. Which of the following would be the most likely place to obtain a copy of a recent deed to a particular tract of land?

    1. State Archives
    2. County clerk of courts
    3. County registry
    4. County public works department

4. The term resolution with reference to a raster or grid data model is defined in terms of:

    1. the ground length of the typical feature
    2. the map length of the smallest feature
    3. the map length of a single pixel side
    4. the ground distance of a single pixel side

Field Equipment & Operations (20)

5. The geodetic heights determined by uncorrected GPS measurements refer first to which of the following?

    1. the geoid
    2. the reference ellipsoid
    3. NGVD
    4. mean sea level

6. In following a survey line with a true bearing of N 80° 15' E, what compass bearing would you use if the magnetic declination for the area was 8° 30' E?

    1. N 88° 45' E
    2. N 84° 30' E
    3. N 76° 00' E
    4. N 71° 45' E

7. To calibrate the optical plummet on a Tribrach, what should be done?

    1. The total station must be calibrated.
    2. The tripod must be level.

3. The tribrach must be level.
4. The tribrach must be rotated 180 degrees.

8. What is the difference in elevation (in Feet) between points A and B in a level loop that had the following observations:

   Point A Elevation = 100.00 feet
   BS = 6.35', FS = 4.78'
   BS = 4.57', FS on B = 2.90'

   1. + 3.24'
   2. + 1.57'
   3. – 1.57'
   4. – 3.24'

9. Level bubble sensitivity is directly affected by:

   1. inside radius of glass tube
   2. placement on instrument
   3. size of bubble
   4. type of liquid in tube

10. The peg method is used to:

    1. make the axis of the plate levels perpendicular to the vertical axis of the instrument
    2. make a telescope on total station plunge to exactly 180 degrees
    3. make the line of sight parallel to the axis of the level tube
    4. make the line of collimation revolve in a vertical plane when the telescope is turned on its horizontal axis.

11. Automatic levels have a self leveling feature that is called a:

    1. Automatic compensator
    2. Parallel plate micrometer
    3. Microscope leveler
    4. Coincident level vial

12. What do slope stakes mark on a route survey?

    1. intersection of design side slopes and natural ground
    2. drainage inverts
    3. slope of a culvert
    4. stations when measuring slope distances

13. In running a traverse line, you are asked to set the next control point, of the following, which would be the most desirable location to set the point?

    1. at a known location so you can find it later
    2. on the crest of a small hill with good visibility both ways
    3. at a point where the instruments operator will be in the shade
    4. in a low gully so that readings are progressively higher and higher

14. When laying out a horizontal curve by deflections from any station on the curve, to facilitate turning to the next station you can backsight the previous station with:

    1. the deflection angle for the previous station sighted on the circle
    2. the deflection angle for the next station to be sighted on the circle
    3. 0° set on the circle
    4. 180° set on the circle

15. A 2-minute error in reading a Horizontal angle means that a point that is set 50 feet away is off by how many feet :

    1. 0.29’
    2. 0.30’
    3. 0.03’
    4. 0.003’

16. - A double rodded line of levels means:

    1. using a micrometer in two directions
    2. using two turning points per set-up
    3. using two levels in one direction
    4. using three wires of level to read rod

17. You have been asked to assist a builder by setting his batter boards. What building feature are you staking?

    1. Finished exterior wall lines
    2. Interior wall lines
    3. floor elevations
    4. Foundation corners

18. To set a grade of a sewer line at station 13+50 (invert = 663.80) a level is set up and reads a backsight of 5.03 on a benchmark (elevation of 672.55). A foresight reading of 1.78 feet is taken on a hub set at that location. What cut reading would you make on a stake at that location?

    1. 12.00
    2. 13.78
    3. 3.80
    4. 3.85

19. In measuring a horizontal angle with a total station the following readings were observed:

    D = 00° 00’ 00”
    R = 180° 00’ 03”
    R = 200° 01’ 07”
    D = 20° 01’ 02”

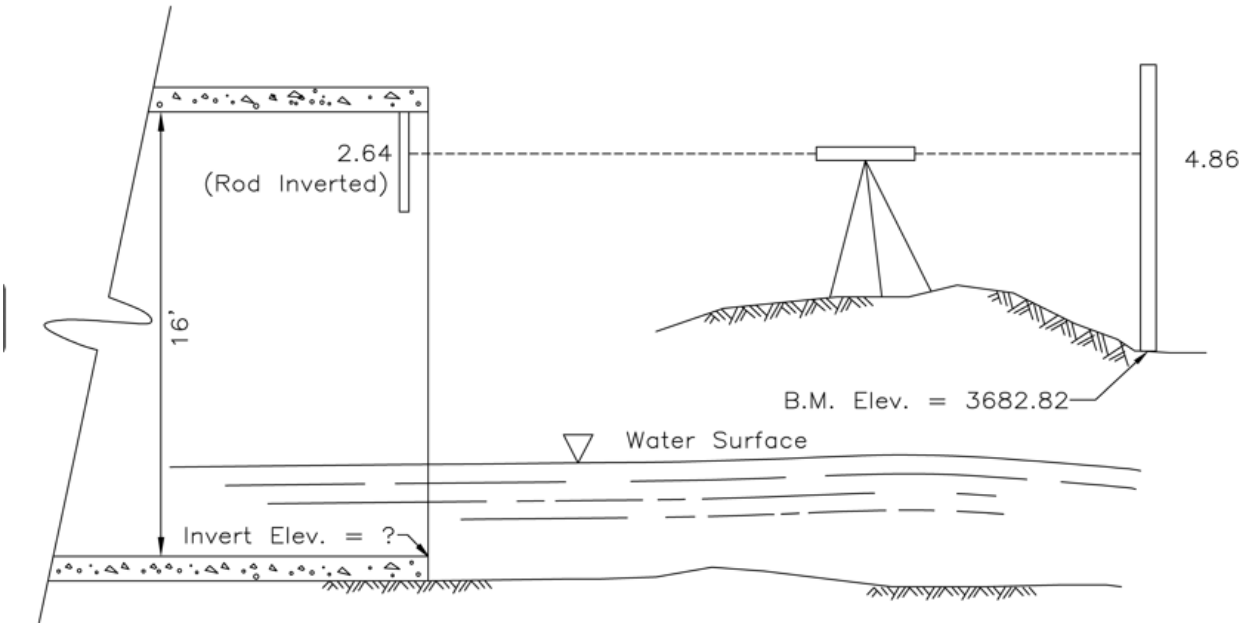
    What is the mean horizontal angle of the above set?

    1. 20° 01’ 03”
    2. 100° 00’ 33”
    3. 180° 00’ 04”
    4. 200° 01’ 06”

20. See Figure 220. It is necessary to determine the invert elevation of a large concrete culvert with an inside height of 16 ft. A direct reading on the floor elevation cannot be made due to the water flowing through the structure. By setting up on the bank of the channel and having the rodperson lean over from the top of the structure with a 6-foot rod, they were able to take a reading on the ceiling of the structure with the rod inverted. Using the readings shown in the figure, what is the calculated invert elevation of the concrete culvert?

1. 3669.04
2. 3674.32
3. 3677.04
4. 3690.32

FIGURE 0220



21. A differential level traverse was run from BM#1 to BM#2 and closed with zero error. The sum of the backsights when totaled was less than the sum of the foresights. This indicates that the:

    1. elevation of BM#2 is lower than BM#1
    2. elevation of BM#2 is higher than BM#1
    3. rod was read incorrectly
    4. one of the BMs is wrong

22. A vertical highway curve has a grade in of +2% and a grade out of -3%, of the following, which will the crew be setting out:

    1. The low point
    2. The mid point
    3. The high point
    4. The vertex of the grades

23. Which of the following is NOT a common mistake in angle measurement work?

1. sighting on, or setting up over, the wrong point
2. calling out or recording an incorrect value
3. improper focusing of the eyepiece and objective lenses of the instrument
4. doubling the angle

24. Stadia cross hairs are used:

1. for three wire leveling
2. when adjusting instrument
3. for determining instrument error
4. for calibrating the instrument

Survey Control (3)

25. In the United States a reference datum for leveling is the:

1. NAVD Datum of 1929
2. NAVD Datum of 1978
3. NAVD Datum of 1988
4. NAVD Datum of 1991

26. What is the Horizontal Control Datum primarily used in North America?

1. NAD 1927
2. GRS 1980
3. NAD 1983
4. WGS 1984

27. On a construction site, vertical benchmarks should be checked:

1. each time a benchmark is used by closing the level circuit back on to that same benchmark.
2. checked each time used if it looks disturbed
3. check each time used with at least one other known point
4. every 100 – 200 feet

Survey Computations (19)

28. To stake the Point of Tangency of a curve in the field you need to calculate the Long Chord of the curve. What is the calculated length of the Long Chord, if the Radius of the curve is 1200’ and the Delta is 20°?

    1. 410.42’
    2. 820.84’
    3. 208.38’
    4. 416.76’

29. The backsight at a station is South 0° East. Projecting forward you turn the following deflection angles: 30° 30’ right; 29° 21’ 15” left; 46° 31’ right. What is the forward bearing of your last line?

    1. S 12° 46’ 15” W
    2. N 44° 02’ 45” E
    3. N 47° 39’ 45” E
    4. S 76° 37’ 45” E

30. The sum of the interior angles of a pentagon (a closed figure with five sides) would total:

    1. 180°
    2. 360°
    3. 450°
    4. 540°

31. What is the grade, in percent, between POT Sta 5+00, Elevation = 125.00 and PC Sta 15+00, Elevation = 100.00?

    1. +2.5
    2. +0.025
    3. -2.5
    4. -0.025

32. A survey line has a bearing of S 21° 46’ 10” E. How many degrees must be turned to go due east?

1. 21° 46’ 10” clockwise
2. 21° 46’ 10” counter clockwise
3. 68° 13’ 50” clockwise
4. 68° 13’ 50” counter clockwise

33. Four wooden piles in line and 15 ft apart are to be driven so the cutoff elevation of each pile is progressively lower than the preceding pile by 1-7/8 inches. If the instrument elevation is 4320.02 and the rod reading on the first pile is 3.78, what is the elevation of the last pile cutoff?

    1. 4315.08
    2. 4315.57
    3. 4315.77
    4. 4316.20

34. A traverse having a total length of 71,392.06 feet failed to close by 0.37 feet in the Northing and 0.53 feet in Easting. What is the relative accuracy of this traverse to the nearest 100 feet?

    1. 1:11,500
    2. 1:110,500
    3. 1:100,000
    4. 1:10,000

35. Assuming an equal instrument height and rod height, calculate the elevation difference for the following observation; 277.55 feet slope distance at a Zenith angle of 90° 57' 50":

    1. + 4.67 feet
    2. - 4.74 feet
    3. +4.74 feet
    4. -4.67 feet

36. The azimuth of line BA is 162° 13' from B to A. The azimuth of line BC is 179° 38' from B to C. What is the clockwise angle from A to C at B?

    1. 162° 35'

2. 17° 25
3. 342° 35'
4. 197° 25'

37. An apparent measured distance of 848.64 feet is marked off with a 100' long tape that is later found to be 0.02 feet too long. What is the actual distance measured?

    1. 848.17 ft
    2. 848.47 ft
    3. 848.62 ft
    4. 848.81 ft

38. A level rod reading of 8.00 feet was taken when the rod, due to an obstruction, was leaning back 6 inches out of plumb at the 8-ft. point. What would the rod reading have been had the rod been plumb?

    1. 7.52
    2. 8.02
    3. 7.98
    4. 8.51

39. The mean of the following distances : 300.56, 300.55 300.53, 300.52, 300.54 equals:

    1 300.56
    2 300.55
    3 300.54
    4 300.53

40. In order to be certain a horizontal highway curve is missing a potential obstruction, you must determine the external distance for the curve which has a tangent distance of 210.38 and a delta angle of 8° 24’. The external distance is:

    1 7.69’
    2 419.62’
    3 420.00’
    4 7.71’

41. Features located horizontally by stadia at a distance of 400 ft. have an accuracy of (plus or minus):

1. 0.5 ft
2. 1.0 ft
3. 2.0 ft
4. 3.0 ft

42. If the pipe is 84 feet long and 48 inches in diameter how many cubic feet of water can it hold?

1. 1056
2. 1075
3. 1218
4. 1510

43. The following interior angles are measured in a closed, 4-sided, traverse;

1. 100° 45' 37"
2. 92° 23' 43"
3. 106° 16' 27"
4. 60° 44' 23"

The angular error of closure is:

1. 0° 00’ 15”
2. 0° 00’ 45”
3. 0° 01’ 05”
4. 0° 10’ 10”

44. For a non right triangle, two interior angles total 159° 10’ 20”. What is the measure of the third angle?

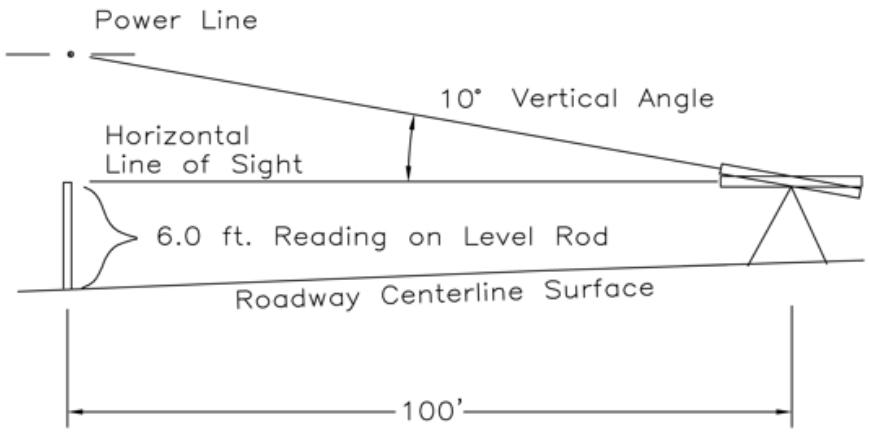
1. 20 49’ 40”
2. 29° 50’ 40”
3. 31° 50’ 40”
4. 200° 49’ 00”

45. See Figure 233. It is necessary to find the height of an electrical transmission line above a roadway centerline surface. You cannot use level rods to determine this height, since it is too dangerous. By placing a total station at right angles to the line crossing and a predetermined distance from the line and measuring the vertical angle to the line,

calculate the vertical distance from the line to the roadway surface. (all units in feet). Using a level rod, you have determined the distance from the horizontal line of sight to the road surface to be 6.0 feet.

1. 17.3
2. 19.6
3. 23.6
4. 28.4

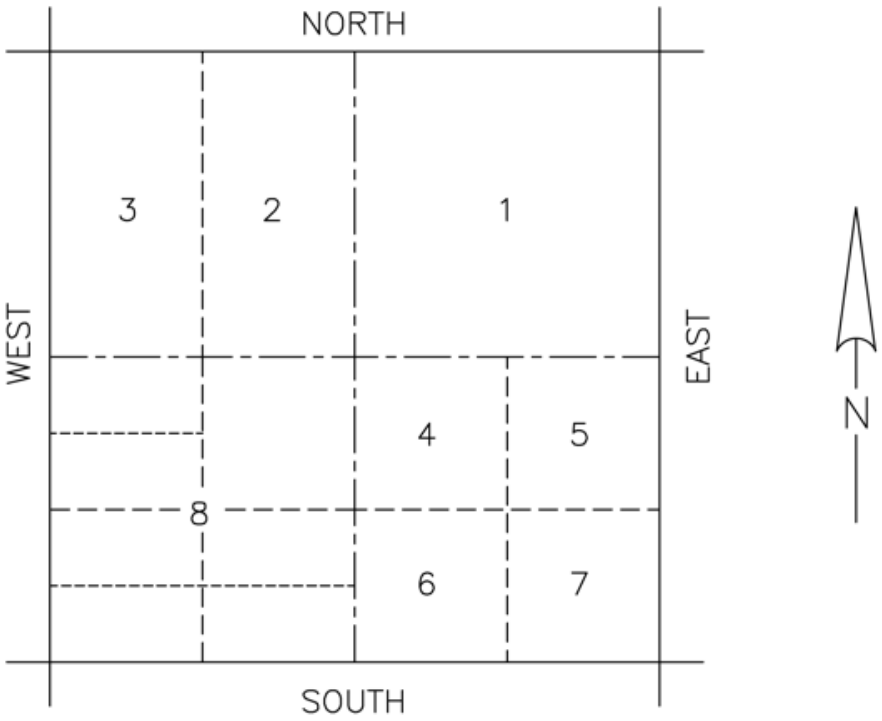
FIGURE 0233



Office Operations, Plan Reading & Preparation (10)

46. See Figure 1295. For the standard section in the rectangular survey system shown, what is the correct description for area 5?

FIGURE 1295



"A STANDARD SECTION"

1. SW quarter
2. SE quarter
3. SE quarter of the SE quarter
4. NE quarter of the SE quarter

47. Contours which are evenly spaced on a map indicate a(n):

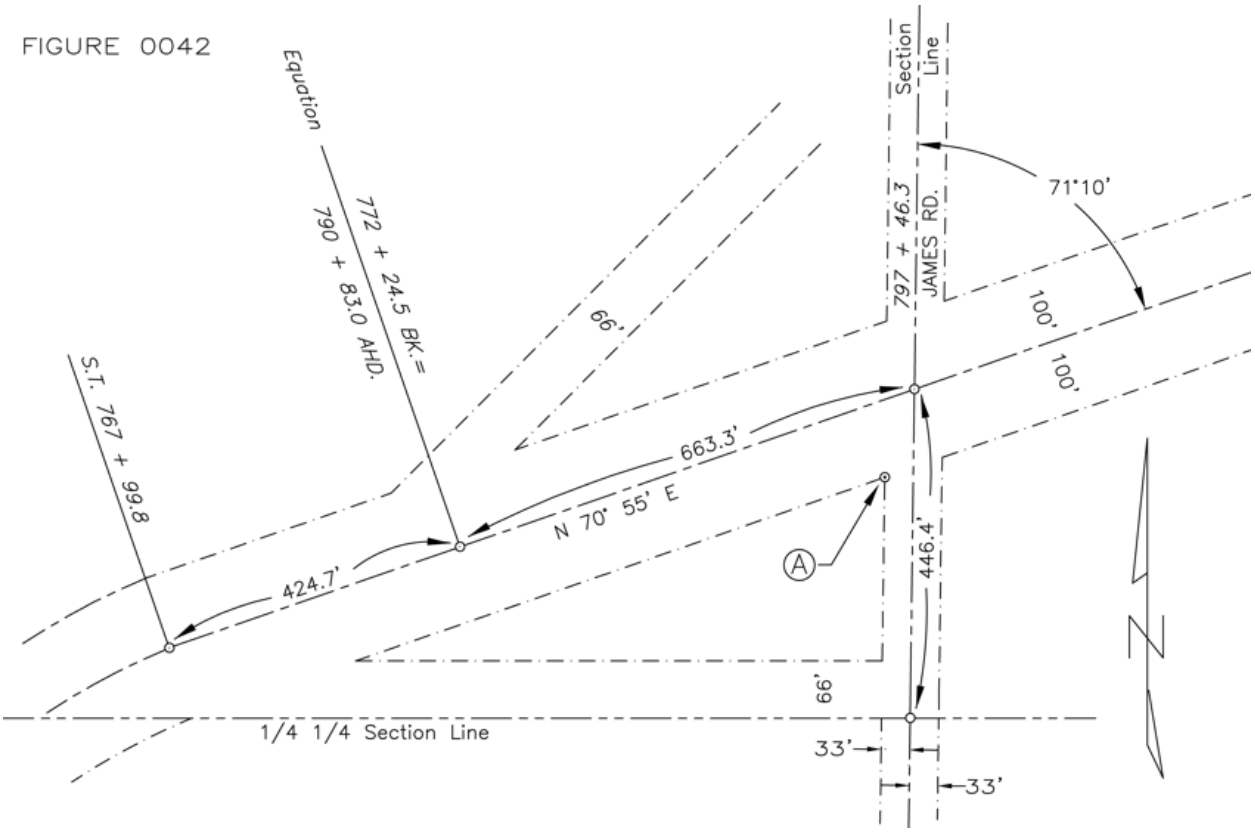
1. change in slope
2. flat slope
3. steep slope
4. uniform slope

48. On a map at a scale of 1” = 2000’ has a contour interval of 20’. What is the slope of a feature that measures 2.67 inches between 4 contour lines?

1. 3
2. 1.5
3. 2.7
4. 1.1

49. Refer to Figure 42. What is the bearing of the centerline of the north south James Road?

1. N 0° 5' E 3
2. N 0° 5' W
3. N 0° 15' E
4. N 0° 15' W



50. To fit a scale of 1:10,000 on an 8 1/2 by 11 inch sheet of paper with a 1” border, what is the largest area, in acres, that can be shown?

    1. 9.32
    2. 932
    3. 93.2
    4. 9,320

51. A closed contour line with hachures on the inside indicate:

    1. a depression
    2. a high point
    3. a lake
    4. a swamp

52. A rectangular borrow area was measured on a map with scale 1 inch = 100 feet. if the area measured 5.7 inches x 8.6 inches, how many acres does the area contain?

    1. 11.3
    2. 15.3
    3. 18
    4. 16.2

53. Contours on a map show elevations at 20 foot intervals and the scale of the map is 1" = 400'. A measured distance between two contours is 1/2 inch. What is the percent of slope of the ground at that point?

    1. 0.5
    2. 10.0
    3. 5.0
    4. 1.0

54. On a proposed road cross section plan you measure the area of fill at one station to be 5.67 square inches. The cross section plan has a horizontal scale of 1” = 50’ and the vertical scale is 1” = 5’ (exaggerated). What is the square feet of fill at this road section

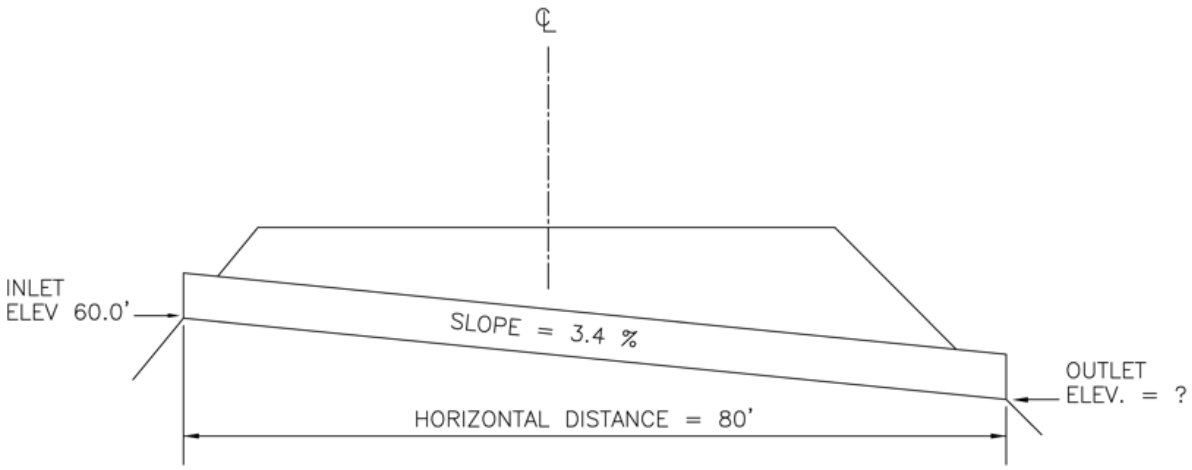
    1. 56.75
    2. 26.83

3. 283.5
4. 1417.5

55. See Figure 30. If the elevation of the 60' road is 70.00' and the slope from the outlet to the edge of the road is 1:1, what is the horizontal dimension from the road centerline to the outlet elevation point?

1. 57.50’
2. 42.72’
3. 47.72’
4. 57.72’

FIGURE 0030



First Aid & Safety (5)

56. When a tornado warning has been issued, persons in the path of the storm should immediately:

1. find shelter in a building and shut all windows tightly
2. sit in a parked automobile
3. stand behind a large tree
4. take cover in an interior area on the lowest floor of building

57. Which of the following is a safe practice around traffic?

    1. Use traffic cones to protect only field equipment.
    2. should wear ear plugs and ear muffs
    3. should use signs to warn motorists of survey activities on the roadway
    4. park a vehicle to block traffic

58. Which of the following is a First Aid Treatment for a simple broken Arm?

    1. Apply a heat pack to the injured area.
    2. Don't stop any bleeding.
    3. Stabilize the arm.
    4. Pull on the lower arm to straighten the break.

59. First aid for a severe laceration of the forearm should be to:

    1. apply an approved tourniquet at the nearest pressure point and transport to the nearest doctor, watch for signs of shock
    2. close the wound and quickly tape shut, cover with gauze bandages and get patient to the nearest doctor, watching for signs of shock
    3. cause the victim to lie down and remain still holding affected part vertical with gauze bandages wrapped around it and call for an ambulance
    4. apply direct pressure and transport victim to medical attention immediately, watch for signs of shock

60. Which of the following articles is NOT the most important when surveying on a roadway?
    1. Hard hats
    2. Reflective vests
    3. Protective goggles
    4. First aid kit

Principles of the Profession (4)

61. The federal agency that specifically developes standards and specifications for geodetic surveys is:

1. National Geodetic Survey
2. National Geographic Information Standards Committee
3. Federal Geodetic Data Committee
4. Federal Geodetic Control Subcommittee

62. The standards that govern the horizontal and vertical accuracy of topographic maps is called the :

    1. National Map Accuracy Standards
    2. Federal Geodetic Contral Standards of Accuracy
    3. National Geodetic Survey Mapping Standards
    4. US Geologic Survey Standards

63. When working in the office where clients and the public see you frequently, the most reasonable rule for how you should dress would be?

    1. Image and practicality
    2. Season and the type of work
    3. Budget
    4. Current weather

64. Licensed or Registered Professional Surveyors:

    1. Have permission to trespass on private property to complete their work
    2. Must meet all local building codes in their work
    3. Must pass National and State examination
    4. Must be members of their State Association

CST LEVEL 2 SAMPLE TEST
ANSWERS

NOTE: *In many instances the answer will reference "Elementary Surveying" 14th edition by Ghilani and Wolf (2015). For example:* G&W 14th p 545. *However, other introductory surveying textbooks should also provide information.*

*The "Definitions of Surveying and Associated Terms" (***Revised Copyright 2005 American Congress on Surveying and Mapping in collaboration with the University of Maine***) abbreviated as* DSAT*, will also be helpful in answering many of the questions.*

Types of Surveys

1.) **#2 The advent of the computer**

Of the answer choices, computer technology was necessary.

2.) **#2 NE ¼, SW ¼ , NW ¼, Sec 15**

Reading the description backwards you get: first the NW ¼ , then the SW ¼ of that, and finally you get to the NE ¼ of that.

3.) **#3 County registry**

Of the choices, the "most likely" and the assured location.

4.) **#4 the ground distance of a single pixel side**

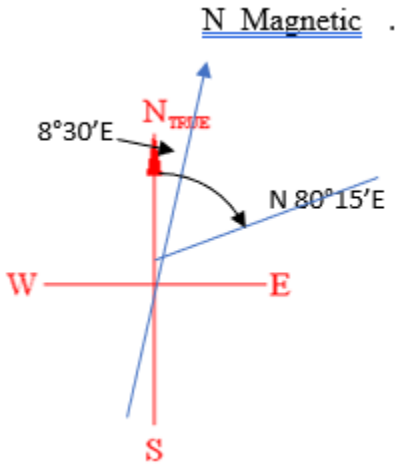
See Brinker and Wolf *Elementary Surveying* 14th Edition, (B&W 14th), page 839

5.) **#2 the reference ellipsoid**

See Brinker and Wolf *Elementary Surveying* 14th Edition, (B&W 14th), page 333

6.) **#4** N 71° 45' E .

80°15' - 8° 30' = 71° 45'NE the Mag. compass bearing



7.) **#4 The tribrach must be rotated 180 degrees.**

See Brinker and Wolf *Elementary Surveying* 14th Edition, (B&W 14th), page 213

8.) **#1 +3.24'**

100 + 6.35 – 4.78 + 4.57 - 2.90 = 103.24 Elev. Of B

So difference in elevation = 103.24 – 100.00 = 3.24

9.) **#1 inside radius of glass tube**

See Brinker and Wolf *Elementary Surveying* 14th Edition, (B&W 14th), page 84

10.) **#3 make the line of sight parallel to the axis of the level tube**

See Brinker and Wolf *Elementary Surveying* 14th Edition, (B&W 14th), page 94

11.) **#1 Automatic compensator**

See Brinker and Wolf *Elementary Surveying* 14th Edition, (B&W 14th), page 88

12.) **#1 intersection of design side slopes and natural ground**

See Brinker and Wolf *Elementary Surveying* 14th Edition, (B&W 14th), page 691

13.) **#2 on the crest of a small hill with good visibility both ways**

answers 1, 3, & 4 may be beneficial in one way or another but good panoramic visibility is an essential necessity not just for running control but for the potential work which follows-experience/deductive reasoning

see Brinker and Wolf *Elementary Surveying* 14th Edition, (B&W 14th), page 228

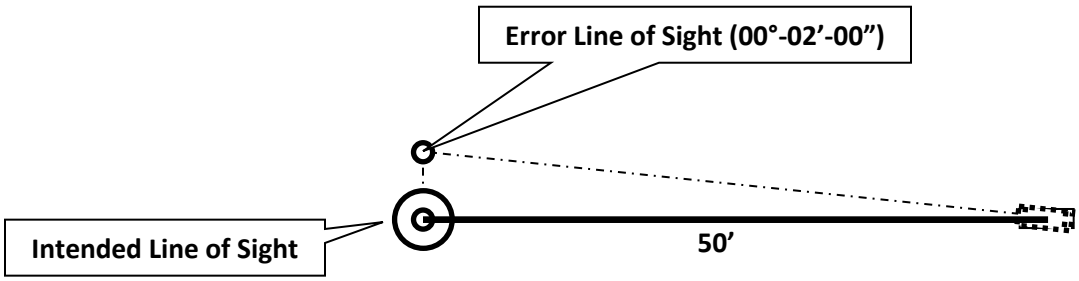
14.) **#1 the deflection angle for the previous station sighted on the circle**

See Brinker and Wolf *Elementary Surveying* 14th Edition, (B&W 14th), page 713 on

15.) **#3 0.03**

Tan 0°02’ = error/50’

0.000581776 = error/50’ so the error = .000581776 x 50’ = 0.02908 ~ 0.03’



Another approach to the solution is to use the Sine of the angle instead of the Tangent

Because the angle is so small the difference in the Tangent and sine functions is negligible

ERROR OF DIST. OFF = SIN OF ANGULAR ERROR × DIST

CONVERT 00°-02’-00” TO DECIMAL DEGREES (0.033333333)

FIND THE SIN OF 0.033333333 (0.000581776)

MULTIPLY 0.000581776 × 50 = 0.029088819

0.029088819is best rounded to answer #3 (0.03)

A good understanding of Right Triangles, Geometry & Trigonometry (Pythagorean Theorem) is essential when dealing with angular errors

"Schaum's Outline of Theory and Problems of Introductory Surveying" Copyright 1985
By James R. Wirshing, Roy H. Wirshing
McGraw-Hill Companies, Inc.
Chapter 3 Horizontal Distances "Tape Alignment" Page 48-49

16.) **#2 using two turning points per set-up**

See Brinker and Wolf *Elementary Surveying* 14th Edition, (B&W 14th), page 107
Also, Definitions of Surveying and Associated Terms (DSAT), p 145

17.) **#4 Foundation corners**

See Brinker and Wolf *Elementary Surveying* 14th Edition, (B&W 14th), page 683, 686

18.) **#1 12.00**

Level Run Reading, Recording, and Computation are involved with this problem. Experience with "Grading Stakeout"-Level Runs will build skill of how to figure Cuts/Fills (Level Run, Figuring Cutsheets & marking Grades on Stakes)

STA	+	HI	-	ELEVATION
BM	**5.03**	**677.58**		**672.55**
INVERT GRADE 13+50			**13.78**	**663.80**
CUT 12' TO GRADE			**-1.78**	
Cut Reading needed			**= 12.00**	

Below is a website with related information:

http://www.dot.ca.gov/hq/row/landsurveys/LSITWorkbook/06.pdf

"Site Surveying"
Copyright 1988, 1995
By John Muskett
Blackwell Publishing
Chapter 2 "Leveling" Page 10

19.) **#1 20° 01' 03"**

Examine the angles recorded and keep in mind how they affect each other. The first angle recorded was (00° 00' 00") on the Backsight target and it was "Direct" (not Plunged or Flopped). This will not affect the next Direct angle recorded since there was not an angle loaded into the Backsight. The second angle recorded (180° 00' 03") was the "Reverse" or "Plunged or Flopped" method of sighting with the telescopic lens in its upside down/reverse view and it was sighted on the Backsight target. This value will be subtracted from the Reverse reading on the Frontsight to find the "Reverse" average or mean value. Lastly, the scope is reset to the Direct view on the Frontsight and that angle is recorded. Since two (2) sets were recorded

(1 Direct and 1 Reverse) then the Corrected Values when totaled will need to be divided by 2. Below is an example of the notes and how they breakdown for computation (Remember to reduce angles to Decimal Format if your calculator does not already do so:

Recorded Angles
D = 00° 00' 00"
R = 180° 00' 03"

R = 200° 01’ 07”
D = 20° 01’ 02”

Find the Corrected Values
D =00° 00’ 00” + 20° 01’ 02” = 20° 01’ 02”
R = 200° 01’ 07” - 180° 00’ 03” = 20° 01’ 04”

Add the Corrected Values and then Find the Average (Mean)
20° 01’ 02” + 20° 01’ 04” = 40° 02’ 06”
40° 02’ 06”÷ 2 = 20° 01’ 03”
20° 01’ 03” Mean Horizontal Angle

A good understanding of Basic Math (adding, subtraction, multiplication, division, etc…) and how to derive Ratios, Proportions, Percentages, Means (Averages) will help when doing this type of Computation. Although now outdated by newer Standards set forth (due to advances in technology and equipment) by the ACSM in 2011 the Format/Method of Direct/Reverse Angle recording and computation is still used today and is used to a higher degree by Government Agencies (NGS, USGS, etc…) which record more than just 2 sets of data. The 1999 Adoption of the ALTA-ACSM Standards by the ACSM/NSPS can be found at the following website (See Note 4 as to the Number of Observations).

http://www.alaskapls.org/standards/surv2.pdf

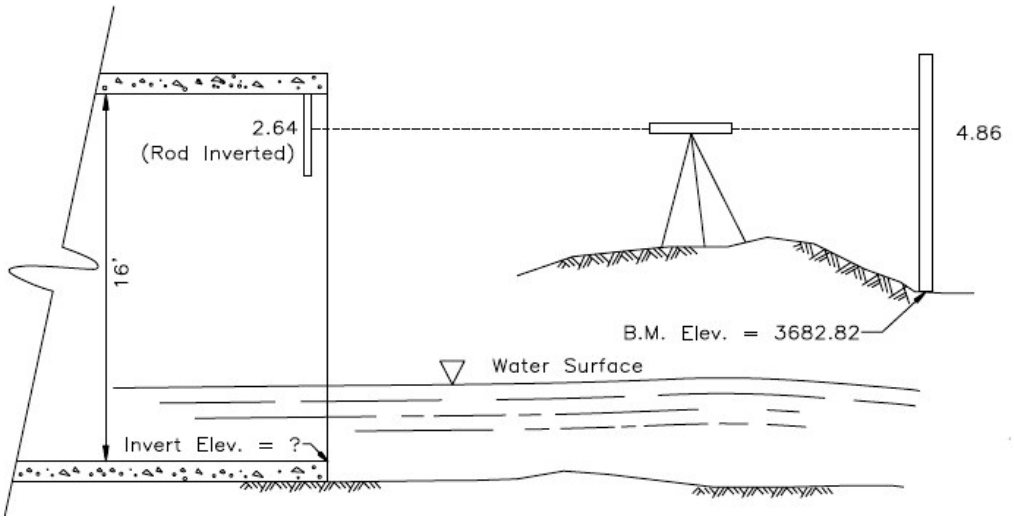
20.) **#2 3674.32**

Level Run Reading, Recording, and Computation are involved with this problem (Note that the rod read on the ceiling of the Structure is inverted. A normal rod read in this case would have been to record a Frontsight shot as a Minus or a value to be subtracted. Since this is not the case and the rod is inverted (upside down), the rod reading will be the opposite of what normally would occur…it is still a Frontsight but it is not recorded as a “negative” value (subtracted) but is now added (positive) to the Height of Instrument (HI).

BM Elev. = 3682.82

STA	+	HI	-	ELEVATION
BM	**4.86**	**3687.68**		**3682.82**
INVERTED CEILING	**2.64**			**3690.32**
Invert Elevation		**3690.32 – 16**		**3674.32**

FIGURE 0220



The following websites have examples of Notes Computations, etc… of Level Runs
http://www.dot.ca.gov/hq/row/landsurveys/LSITWorkbook/06.pdf

http://onlinemanuals.txdot.gov/txdotmanuals/ess/differential_leveling.htm

"Site Surveying"
Copyright 1988, 1995
By John Muskett
Blackwell Publishing
Chapter 2 “Leveling” Page 10

21.) #1 elevation of BM#2 is lower than BM#1

Since Foresights are read as a subtracted value, (minus/negative….unless the rod is inverted as in the case of Problem #31) and their total is greater than the Backsights (positive or addition) then the elevation would have had to decrease (more negative values vs. positive value indicates the elevation has dropped or decreased). See Chart Below

STA	+	HI	-	ELEVATION
BM #1	5.50	105.50		100.00
TP-1			10.60	94.90
“ “	4.50	99.40		
BM #2 CK			8.35	91.05
BM #2 ELEV				91.05

ERROR				**(0.00)**

In addition to the references from Problem #31 (which can be applied to this problem) below is another Book/Chapter that covers different Types of and Methods of Leveling

"The Surveying Handbook"
By Russell C. Brinker & Roy Minnick
2nd Edition Copyright 1995
Kluwer Academic Publishers
Chapter 7 Leveling Page 113

22.) #3 the High point Check this answer

Since the grade going in to the vertical curve is a plus (+) and the grade going out of the curve is a (-), we know that this is a "crest" and not a "sag" curve. So, there can be no low point in this curve.

Also, unlike a horizontal curve, the point of intersection of the tangent grades is only a theoretical point and not set - it would be in the air (or under the ground in the case of a sag curve).

Also see Ghilani and Wolf, 14th Edition, p 749

23.) #4 doubling the angle

This problem focuses on the word "mistake" to stress the difference between it and "error". See Ghilani and Wolf, 14th edition, pages 44-47 for a discussion.

Essentially an error is either systematic (a result of a "bias") or random; which are "caused by factors beyond the control of the observer".

A mistake, on the other hand, is a "blunder" and the result of "carelessness, fatigue, poor judgement or missed communication"

When you look at the available answers for this question you will see that all but #4 are really mistakes and #4 is a random error due to the inability to always sight to exactly the same point.

"Definitions of Surveying & Associated Terms"
Revised Copyright 2005 see pages 34, 99 and 171.
American Congress on Surveying and Mapping in collaboration with the University of Maine

24.) **#1 for three wire levelling**

See Ghilani and Wolf, 14th Edition, p 119 and 556

25.) **#3 NAVD Datum of 1988**

See Ghilani and Wolf, 14th Edition, p 536-537

26.) **#3 NAD 1983**

See Ghilani and Wolf, 14th Edition, p 589-590

27.) **#3 check each time used with at least one other known point**

"In the process of leveling, there are usually opportunities to check into other benchmarks along the loop. Whenever, possible, this should be done as a double-check …" this shows that verifying the work being performed between two vertical control points minimizes mistakes and errors

"Construction Surveying and Layout"
Copyright 2003
Wesley G. Crawford
Creative Construction Publishing, Inc
Chapter 7 Subtitle "Standard Practices-Check into Other Benchmarks" from page 17-6

28.) **#4 416.76**

From Horizontal curve formula: Length of curve LC = 2Rsin Delta/2)

Where: R is the curve radius

Delta is the intersection angle (sometimes referred to a I or Δ)

So, LC = 2(1200)Sin20°/2

(2450)(0.17365)=416.76'

29.) **#3 N 47° 39' 45" E**

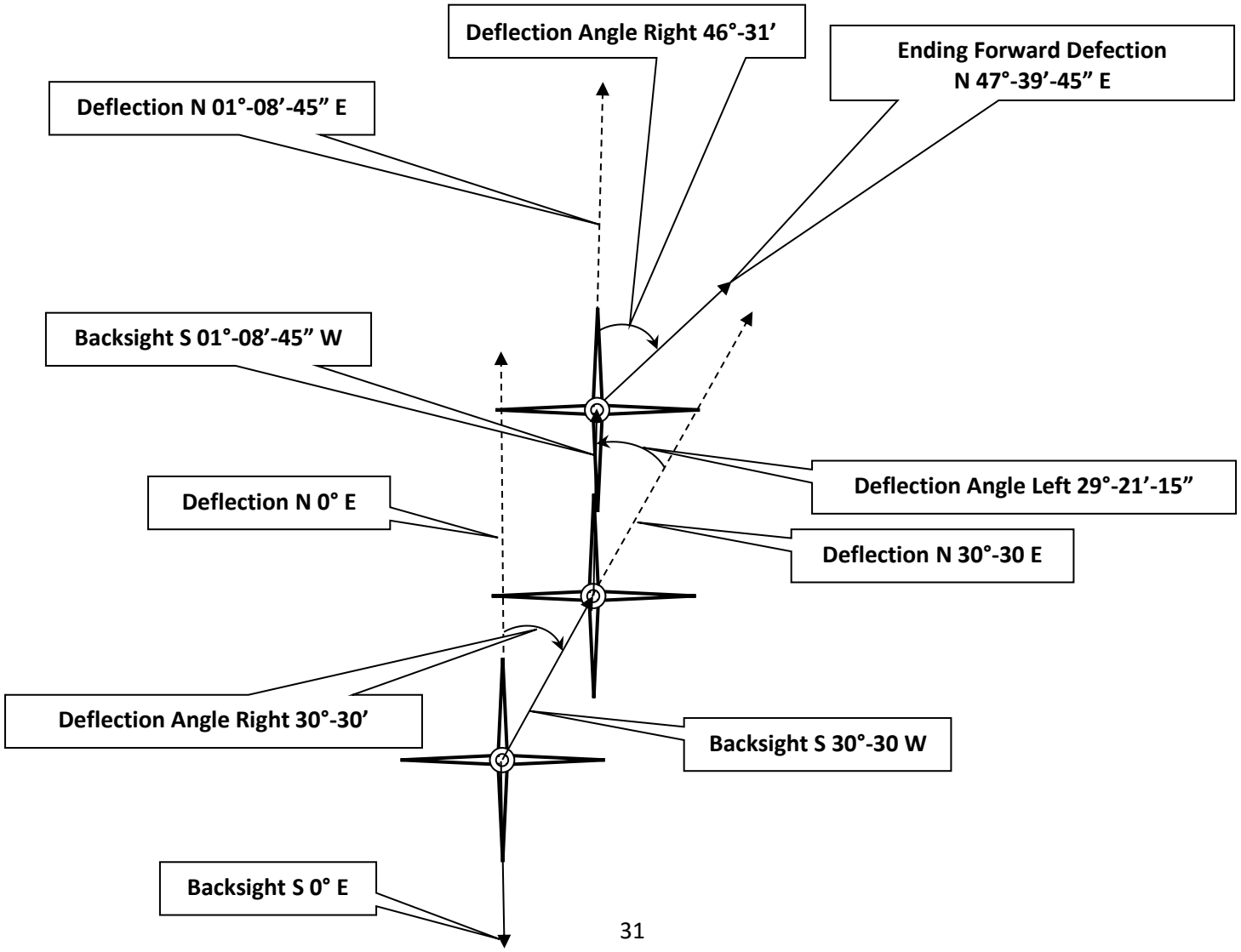
Note: In surveying, a horizontal angle measured from prolongation of the preceding “line of sight” to the next line; recorded as “right” (positive) if clockwise rotation and “left” (negative) if counterclockwise. Adding these angles up using their respective algebraic signs (+ or -) and then adding it to the beginning Backsight will reflect the ending line of sight or Forward Bearing. Converting the angles to Decimal Degree format will be necessary:

Decimal Degrees of 30°-30' Right = 30.5 (+)
Decimal Degrees of 29°-21'-15" Left = 29.35416667 (-)
Decimal Degrees of 46°-31' Right = 46.51666667 (+)

Next, add the angles using the algebraic signs to the Beginning Backsight/Deflected Bearing of S 0° E:

0 + 30.5 + -29.35416667 + 46.51666667 = 47.6625

Next, convert the “new” Bearing Heading to Degrees, Minutes & Seconds 47°-39’-45”. Using a sketch to evaluate the angles turned will give a visual perspective to “see” where the angles eventually end up. (See Figure Below)



"Elementary Surveying: An Introduction to Geomatics"
12th Ed. Copyright 2008
Charles D. Ghilani, Paul R. Wolf
Pearson Prentice Hall
Chapter 8 Observing Deflection Angles (Sub Chapter 8.11 Page202)

30.) **#4 540°**

General equation for number if interior angles in a polygon is **(**n-2)180°

where n is the # of sides

So in the case, with a five sided figure, (5-2)180°=3*180°=540°

31.) **#3 -2.5**

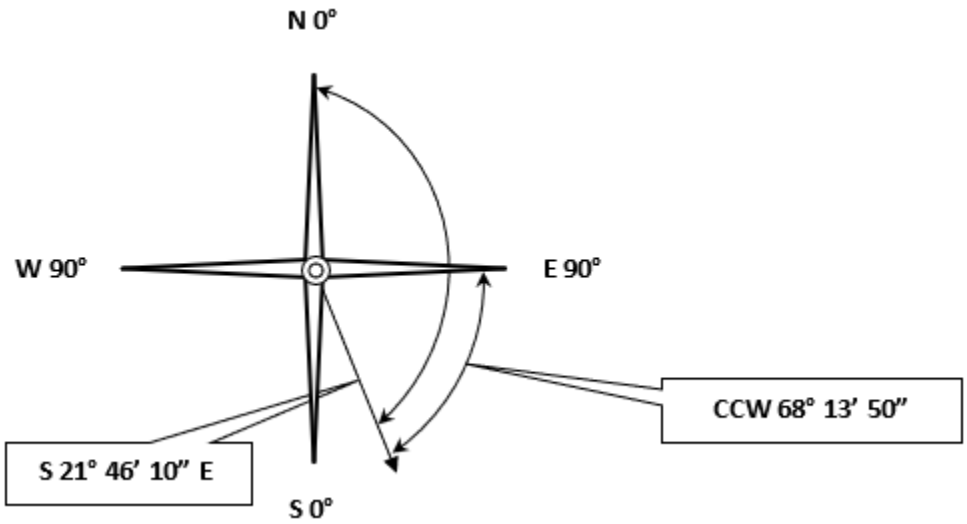
Chapter 17-18 Calculate the gradient by Construction Surveying & Layout by Wesley Crawford

The # of station from the POT to the PC is: 15+00 + 5+00 = 10+00 or 1000 ft

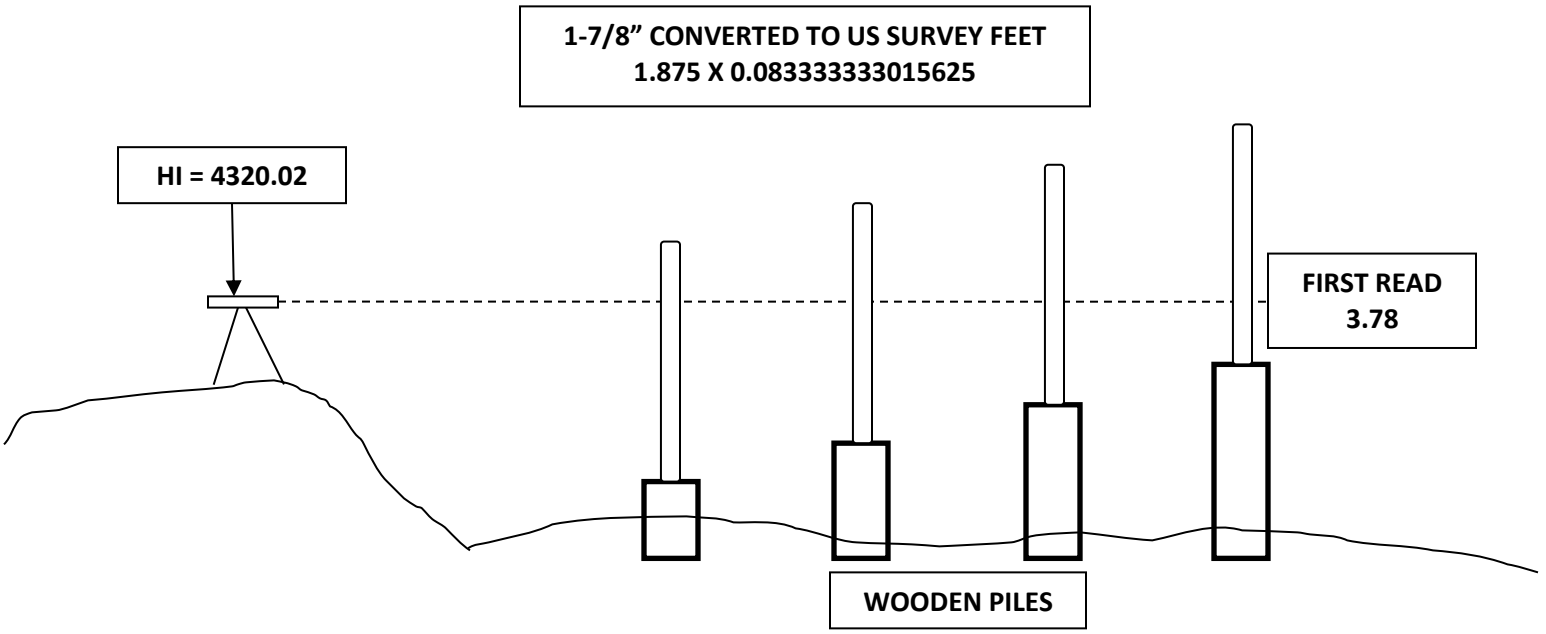
The difference in elevation between these two stations is: 125.00 – 100.00 = 25.00 ft lower

So, the slope between them is: 25' ÷ 1000' = 0.025 or -2.5% since the slope is down

32.) **#4 68° 13' 50" counter clockwise (See Figure Below)**



33) #3 4315.77 (See Figure Below)



0.15625 X 3 = 0.46875
(3 PROGRESSIVELY LOWER)
4320.02 – 3.78 = 4316.24 (1ST PILE)
4316.24 – 0.46875 = 4315.77125
(4315.77 BEST ANSWER)

There is not any one definitive Book or Media source to mention for this particular problem, as it requires several methods & procedures of operation to arrive at the correct answer. A proficient math course that is designed for Surveying & Engineering is a good foundation to start with. Experience with using a level is also paramount.

34.) **#2 1:110,500**

Using the Formula for Error of Closure: $Ec = \sqrt{\text{ERROR NORTHING}^2 + \text{ERROR EASTING}^2}$

Relative Accuracy = Total Length/Ec

$$\text{TOTAL LENGTH} \div \sqrt{\text{ERROR NORTHING}^2 + \text{ERROR EASTING}^2}$$

$$\text{TOTAL LENGTH} \div \sqrt{0.37^2 + 0.53^2} \text{ or } 0.646374504$$

Relative Accuracy = 71392.06 ÷ 0.646374504 = 110449.9938 Rounded up to 110,500

"Elementary Surveying: An Introduction to Geomatics"
12th Ed. Copyright 2008
Charles D. Ghilani, Paul R. Wolf
Pearson Prentice Hall
Chapter 10.6 Page 246 Table 10.3

35.) **#4 - 4.67 feet**

Right Triangle Solution:

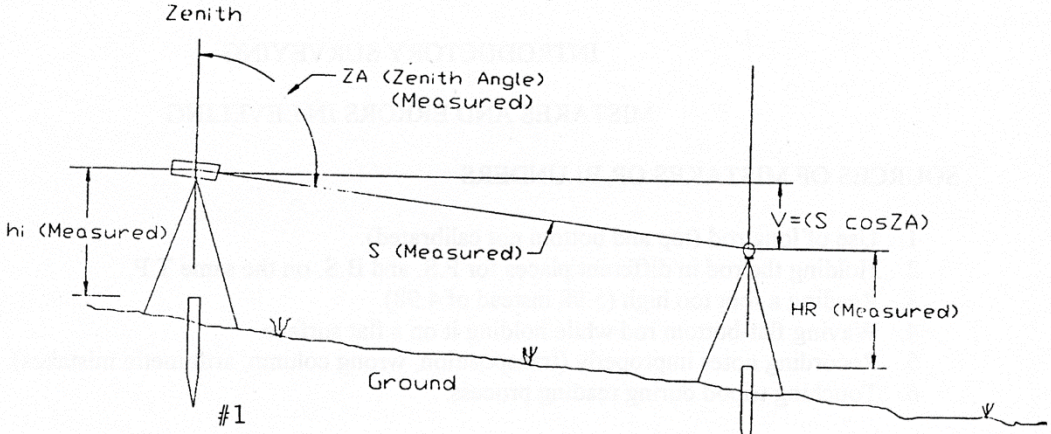
Vertical Distance (V) is equal to the Slope Distance times the Cosine of the Zenith Angle

Solution: 277.55 Cos 90° 57' 50"

V = (277.55)(0.0016822)

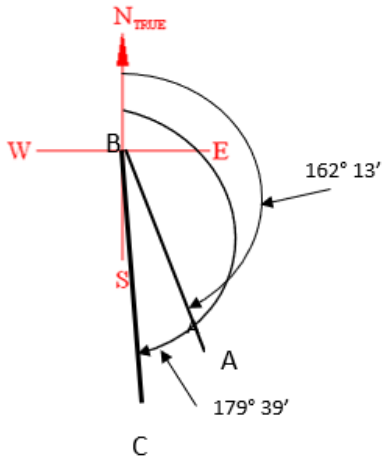
V = - 4.669' or - 4.67'

Since the hi and HR are the same in this instance, the difference in elevation = V



PROBLEM #1 Instrument at Trav. Sta. (1) Backsight on Benchmark (A)

36.) **#2 17° 25**



Azimuth BA = 162° 13'

Azimuth BC = 179° 38'

Angle ABC = 179° 38' - 162° 13' = 17°

37.) **#4 848.81**

When you measure a distance between two points with a tool that over measures, you end up under-recording (because you are just reading what the tape is showing). So, the correction must be added to the "recorded" distance to get the "true" distance.

(However, when you are measuring off, or laying out, a distance as you are in this case (848.64 feet). The opposite with be true. Your tape reading will be too high and so you must subtract the correction.)

In this case we have a **correction** to length of Cl =(l – l')/l' x Length

Where l' = named length of tape (100') in this case

l = actual length of tape (100.02 in this case)

L = the recorded length of the line

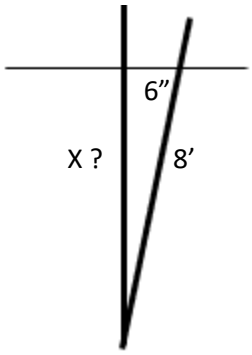
So Cl = [(100.02 – 100)/100] / 848.64 = 0.1697

Since this is a case where you are measuring an existing length, the correction must be added to the "recorded" measurement. Your tape being too long has caused you under record.

So the actual measurement between the two points is 848.64 + 0.17 or 848.81 feet.

See Ghilani and Wolf. 14th Edition, p 137

38.) **#3 7.98**



Using the Pythagorean Theorem X =

$X^2 = 8'^2 - 0.5'^2$ =

So $X = (64 - 0.25)^{1/2} = 7.984$

39) **#3 300.54**

Adding up the five measurements give a total of 1502.70

Dividing by the number of measurements (5) will result in the average or mean

1502.70/5 = 300.54

40) **#4 7.71'**

The formula for the External Distance of a horizontal curve is: E = (T) Tan(I/4)

So, in this case, E = (210.38') Tan (8°24'/4) = (210.38')Tan (2.10°) = 7.71'

Also see G & W 14th ED., p 711-713

41) **#2 1.0 ft**

In general Stadia distance are assumed to be accurate to +/- one foot.

Per B & W 14th, p 129 "An accuracy of 1/500 is achieved with reasonable care"

So for a 400 ft distance: 1/500 = X/400 or x = 0.8 or **+/- 1.0 ft** answer

42) **#1 1056**

The formula for the volume of a cylinder is $V = \pi r^2 h$

In this case, the radius is 24" or 2 ' so V = (3.14159) $(2.0'^2)$(84') = 1055.6 or **1056**

43) **#4 0° 10' 10"**

The sum of the four angles turned is equal to: 360° 10' 10"

For a four-sided figure, the sum of the interior angles should be N-2(180°) or 4-2(180°)

Or 360° 00' 00".

In this case the total turned angles total 10' 10" in excess, so the angular error is **10' 10"**

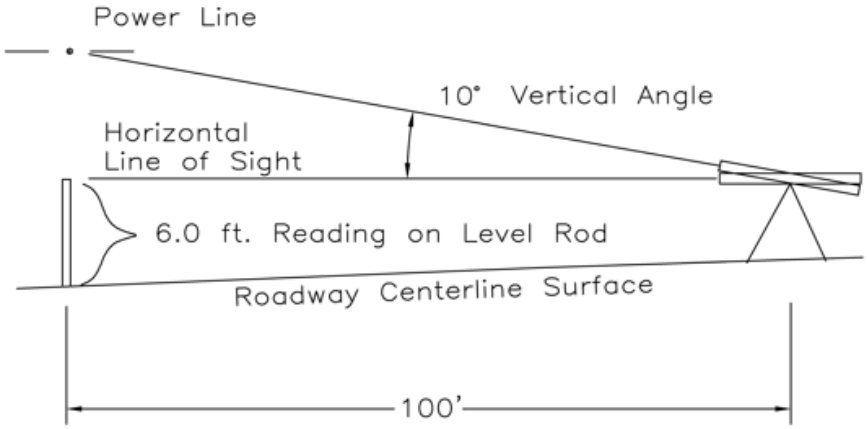
44) **#4 20° 49' 40"**

A triangle (3 sides) should have interior angle totaling 180° 00’ 00”.

In this case the third angle should be 180° 00’ 00” - 159° 10’ 20” = **20°49’ 40**

45) **#3 23.6**

FIGURE 0233



The missing vertical distance (from horizontal line of sight to the power line) can be calculated using the formula: Tan 10° = X/100’ so X = (0.176326981) (100’) = 17.63’

Adding 17.63 to the 6’ from level line to the ground, the total height of the power line **= 23.6’**

46) **#4 NE quarter of the SE quarter**

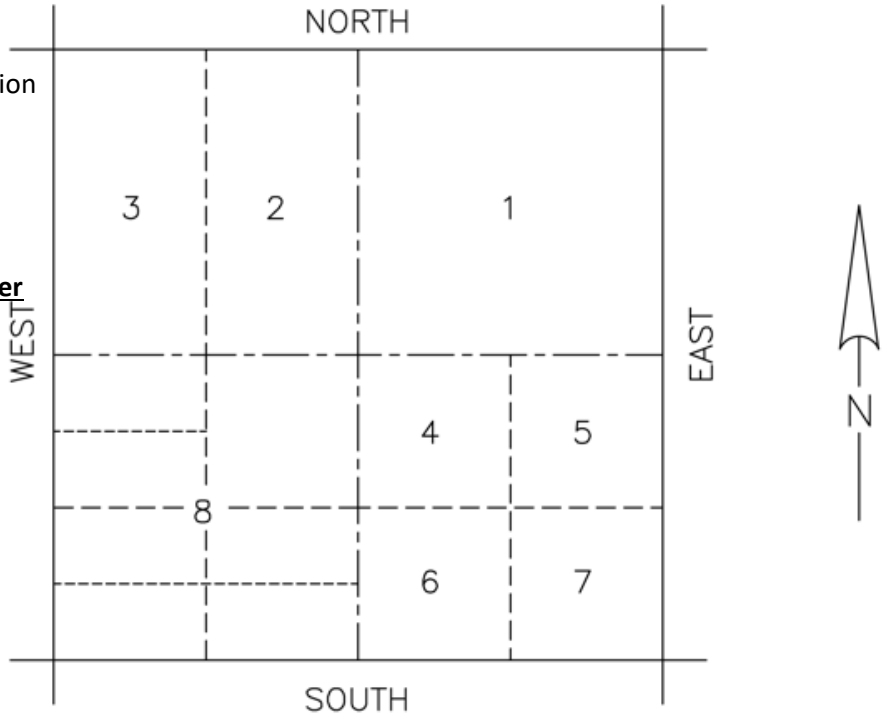
FIGURE 1295

Area 5 is in the SE ¼ of the Section

And it is in the NE ¼ of that ¼

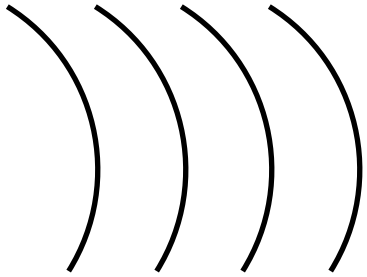
So description would read:

The NE quarter of the SE quarter



”A STANDARD SECTION”

47) **#4 uniform slope**



Since the distance between contours, the

"contour interval" represents the vertical distance

between the contours,

contours that are evenly spaced indicate

And area where the **slope is uniform**

See Ghilani and Wolf, 14th Ed., p 465 - 467

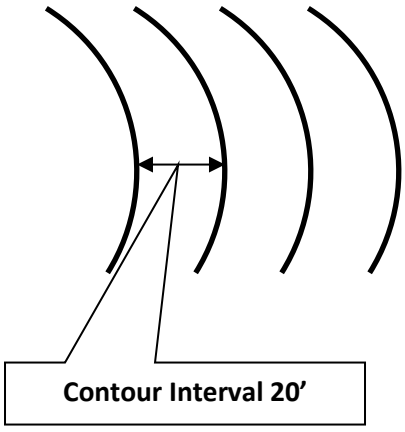
48) **#4 1.1**

Understanding Ratios, Proportions, and Percents will help with this problem, so a good knowledge of Fractions, Whole Numbers, And Decimal Functions and how to arrange values to derive the correct answer is essential. Comprehension of Topography, Mapping, Contours, Scaling, and Drafting is also fundamental in order to discern the relationship of mapping symbology and their position (Vertical and Horizontal).

First, finding the relative value of 2.67 inches on this particular map is needed. The map is a scale of 1" = 2000' therefore multiply:

$$2.67'' \times 2000'/' = 5340$$

Now what is needed is to find what the distance between four (4) contour lines are. (See Figure Below)



Since there are four lines this creates three parallel lines of contour of 20’ each. Therefore multiply the three spaces by the distance that separates them:

$$3 \times 20 = 60 \text{ ft}$$

Next take these values and use them to find their relationship to each other (how 60’ of slope contours relates to 5340’ of horizontal distance) This will give the slope value in decimal format:

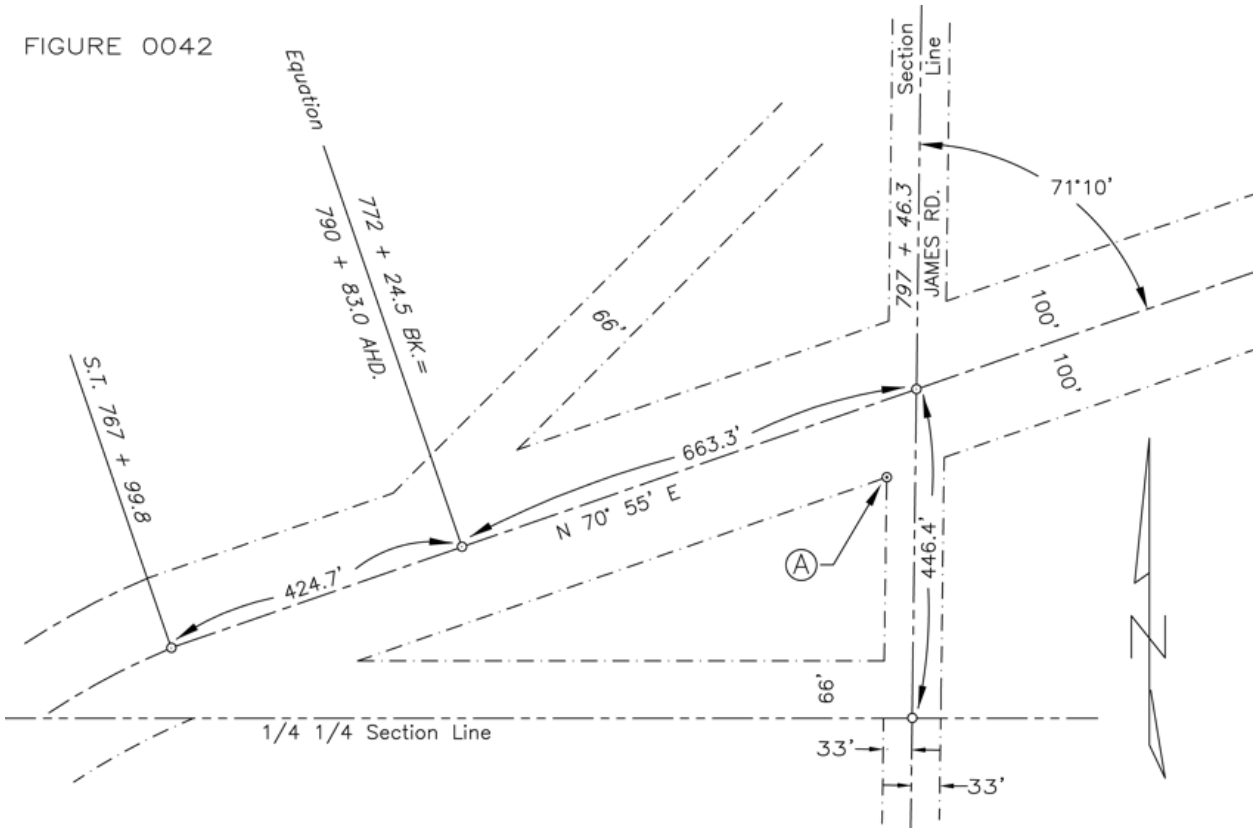
$$60 \div 5340 = 0.011235955 \text{ ft/ft}$$

Next multiply this value by 100 to find the value in Percent of Slope:

$$0.011235955 \times 100 = 1.123595505\%$$

Reduce to 1.1% the most reasonable answer provided. There are far too many references to mention for this particular problem. It requires a broad general knowledge of several aspects of Surveying & Mathematics

49) **<u>#4 N 0° 15’ W</u>**



From the plan there is no bearing given directly for James Road.

But it can be calculated because the bearing for the intersecting road is given: N 70° 55’ E

In addition, the angle between that centerline and the James Road centerline is also shown on the map: 71° 10’..

So, the bearing of James Road = 70° 55’E - 71° 10’ = - 0°15’ or **N 0° 15’ W**

50) #2 932

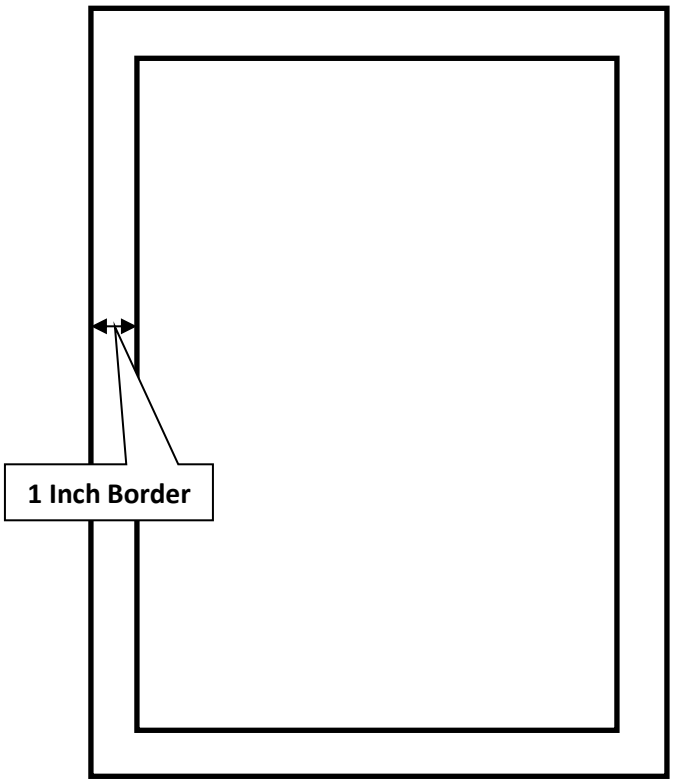
The scale here is as a representative fraction. It is not inches but 1’ is equal to 10,000’ but the paper is in Inches so a conversion is needed. One foot is equal to 12” and now a relationship can be found by dividing 10,000 by 12: (10,000 ft)(12 inches/ft)

10,000 × 12 = 833.333333333 so the equality scale is 1” = 833.333333 ft

This value needs to be squared since the dimensional value is for an Area:

So 1 in^2 = $(833.333333333\ ft)^2$ = 694,444.444443888 ft^2 per square inch

Next, the size of the paper will determine the area able to be plotted (drafted). The paper is 8 1/2 by 11 inches. The border trim is 1” so some alteration in size is needed. (See Figure Below)



8 1/2” by 11” Sheet
1” Border

8.5” – 2” = 6.5”

11” – 2” = 9”

Find the square value of the Plot Area

6.5 x 9 = 58.5 square inches

Next, multiply the converted scale value by the Plot Area to find the value in feet squared:

694,444.444443888 ft squared per square inch × 58.5 sq. inches = 40,624,999.9999675 ft sq

Now convert to Acres (43560) by dividing:

40,624,999.9999675 ft sq ÷ 43560 ft sq per acre =932.621671257 acres

Round off to **932 Acres the best answer offered**.

51) #1 a depression

See Ghilani and Wolf 14th Ed., p 467

52) #1 11.3

For a scale of 1" = 100 ft,

5.7" on map would be 570 ft on the ground

and 8.6" on map would be 860 ft on the ground

These two distances would encompass a ground are of 570 x 860 = 490,200 ft squared

With 43,560 ft^2 per acre, 490,200 ft^2/43,560 ft^2/acre = 11.25 or **11.3 acres**

53) #2 10.0

For a map with a scale of 1" on map = 400 ft. on ground, ½ inch would represent 200 ft on the ground.

If this is the distance between two contours 20 ft vertically apart, then the slope at that point would be calculated as (rise/run) 20'/200' = 0.10 '/' or a % slope of **10%**

54) #1 1417.5

The 5.67 square inches measured for fill at this road section cannot simply be multiplied by a single scale since it is depicted at two different scales: H 1"=50' and V 1"=5'.

So a square inch on this plan would be 50' by 5' or 250 ft^2

Thus the 5.67 square inches measures would be: 5.67 x 250 = **1417.5 ft^2**

55) **#2 42.72**

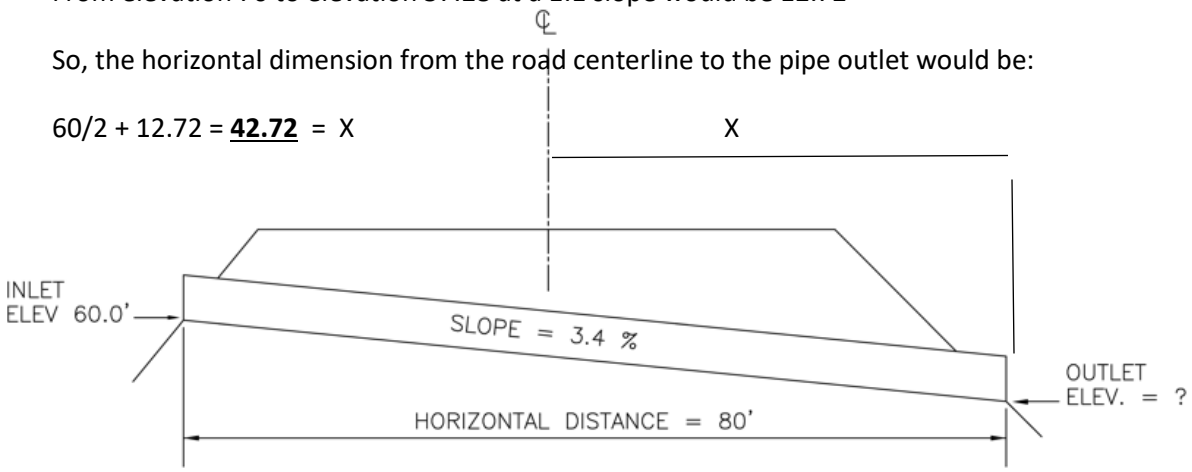
FIGURE 0030

First the outlet elevation of the culvert: 60.0 – (.034)(80) = 57.28

From elevation 70 to elevation 57.28 at a 1:1 slope would be 12.72'

So, the horizontal dimension from the road centerline to the pipe outlet would be:

60/2 + 12.72 = **42.72** = X



56) **#4 take cover in an interior area on the lowest floor of building**

Of the answers available, numbers 1, 2, and 3 all have obvious dangers in protection from a tornado, which make answer #4 the best choice

see https://www.cdc.gov/nceh/features/tornadosafety/index.html

57) **#3 should use signs to warn motorists of survey activities on the roadway**

For the protection of the field personnel and equipment, of the possible selections, the answer #3 would provide the most overall protection by combining signage and alerting the passing motorist to take care.

58) **#3 Stabilize the arm.**

From the Mayo Clinic: https://www.mayoclinic.org/first-aid/first-aid-fractures/basics/art-20056641

1. Stop any bleeding. Apply pressure to the wound with a sterile bandage, a clean cloth or a clean piece of clothing.
2. Immobilize the injured area. Don't try to realign the bone or push a bone that's sticking out back in. ...

3. Apply ice packs to limit swelling and help relieve pain. ...
4. Treat for shock.

So answer #3 is the only choice that is correct.

59) **#4 apply direct pressure and transport victim to medical attention immediately, watch for signs of shock**

Of the possible answers, #2 and #4 appear to be closely similar. The key difference is that answer #2 suggests taping shut the wound and covering with gauze bandage and #4 excludes this. The situation posed mentions that it is a "severe" laceration of the forearm and this is why direct pressure is needed and not a simple bandage.

60) **#3 Protective googles**

While all of the items mentioned might be useful of the possible selections, the protective googles would be the least important.

61) **#4 Federal Geodetic Control Subcommittee**

See Ghilani and Wolf, 14th Edition, pages 108, 323

Also https://www.fgdc.gov/organization/working-groups-subcommittees/fgcs

62) **#1 National Map accuracy Standards**

See Ghilani and Wolf, 14th Edition, pages 498, 507

63) **#1 Image and practicality**

As the question poses a situation where you are" working in an office where clients and the public see you frequently", the best choice is #1 in that it covers all the others plus improves the impression of land surveyors for the clients and the public who see you.

64) **#3 Must pass National and State examinations**

While in some jurisdictions, surveyors have a 'right of entry" permission, this is not the case in all states. Also, there is no requirement that licensed surveyors become members of the state associations. Finally, surveying does not involve work that falls under local building codes