NSPS

SURVEY TECHNICIAN CERTIFICATION PROGRAM

LEVEL II
SAMPLE EXAMINATION QUESTIONS
ANSWERS & GUIDE

NSPS CST CERTIFIED SURVEY TECHNICIAN

NATIONAL SOCIETY OF PROFESSIONAL SURVEYORS

Revised July 2018

This booklet has been prepared to provide an example of what an actual Certified Survey Technician (CST) Examination might be like. In addition to the sample exam, it includes the answers to the sample questions given. Examples of where to find resources to solve these sample questions are given as well to aid the "student". Using this as your only study guide is not recommended.

This sample examination is 25% of an actual exam. The work element order is the same as in the full examination with approximately one quarter the number of questions.

These are not actual 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
  5119 Pegasus Court, Suite Q
  Frederick, MD 21704

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). A Surveying and Mapping Dictionary

WORK ELEMENTS

Test problems will be taken from the following work elements:

F = Field O = Office

1) Types of Surveys (F=10; O=10)

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

2) Field Equipment & Instruments (F=35; O=15)

Knowledge of the care, cleaning, and use of a variety of surveying tools and equipment including field radios. 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. This would include repeating observations. Some historical knowledge is required.

3) Survey Computations (F=40; O=55)

Knowledge of trigonometry, geometry, algebra, coordinate geometry, and basic surveying computations. A familiarity with hand held calculators and micro-computers is important. With either a hand held calculator or micro-computer software, be able to enter field data and produce positional information (i.e. leveling, traversing, stadia, topographic mapping, and construction stakeout). Demonstration of 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. Have an elementary comprehension of computer operating systems and GIS.

4) Control Points: Horizontal & Vertical (F=10; O=10)

Know how to interpret control point records and data sheets, as well as locate points in the field.

5) Field Operations (F=35; O=10)

Under the supervision of a party chief, be able to coordinate field work for a variety of standard types of surveys. Know how to observe the Sun and Polaris for True North determination. Know basic sources of measurement errors. Know principles of staking and stake markings. Know procedures for GPS surveys.

6) Field Notes (F=10; O=10)

Know how to keep neat and orderly field notes for standard surveying operations: leveling, traversing, topographic mapping, layout, as-built surveys, boundary surveys, profile, and cross-section surveys.

7) Plan Reading and Preparation (F=15; O=45)

Knowledge and understanding of the basic plan reading and preparation (i.e. site plans, boundary plans, highway plans, profile and cross-section, horizontal and vertical curves, pipeline plans, foundation plans, and developing existing and finishing contours). A basic knowledge of the terminology and principles of drafting, including computer-aided drafting (CAD).

8) Principles of the Profession (F=10; O-10)

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.

9) First Aid & Safety (F=15; O=15)

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.

CST LEVEL II SAMPLE TEST

Types of Surveys

1. In a route survey, a station is:

    1. the headquarters for the project
    2. a point to set up the Total Station when performing the control traverse
    3. any point along a centerline measured from the point of the beginning
    4. a point located by resection methods

2. The standard dimensions of the SW ¼ of the SW ¼ of the SW ¼ of a section are ___feet by ___ feet.

    1. 2640, 2640
    2. 660, 660
    3. 1320, 2640
    4. 1320, 1320

3. To prolong a survey line in a direction ahead of your current set up the best results would be achieved by:

    1. doubling a 180° angle to your foresight point
    2. double centering a series of points to set the foresight
    3. turn angles at least four times
    4. use equal angle method

Field Equipment & Instruments

4. A GPS Satellite has an approximate orbital time of:

    1. 2 days
    2. 6 hours
    3. 12 hours
    4. 24 hours

5. A “two-pole” chain is:

    1. the length of a Gunter chain
    2. 33 feet long
    3. the basis of original survey of nearly all government lands
    4. 66 feet long

6. Which of the following tapes will lay out a distance longer than actual?

    1. tape supported only at ends
    2. tape shorter than standard
    3. tension less than standard
    4. temperature 30° above standard

7. What is the true difference in elevation (in Feet) between two points in a two-peg test of a level? The following observations were made:

    Instrument at mid-point between A and B reading on A = 6.35, reading on B = 4.78. Instrument at B reading on A = 4.57, reading on B = 2.90

    1. 1.57
    2. 1.62
    3. 1.67
    4. 1.79

8. Which of the following is <u>INCORRECT</u> in reference to the setting up and using a surveyor’s instrument?

    1. use light pressure when pushing tripod legs into the ground
    2. on a side hill location, two of the tripod legs should be on the downhill slope
    3. while making an observation, the body should not be in contact with the instrument
    4. the instrument operator should not tighten the adjusting and leveling screws as tight as possible

9. When the bubble of a level is centered:

    1. the axis of the level tube is perpendicular to the vertical axis
    2. the horizontal crosshairs lie in a plain perpendicular to the vertical axis

3. the line of sight is perpendicular to the axis of the level tube
4. the axis of the level is perpendicular to the horizontal axis

10. The reason most survey instruments go out of level is:

    1. settlement of the tripod
    2. kicking the tripod
    3. putting a hand on the instrument
    4. walking around the instrument

Survey Computations

11. A NGS station whose coordinates are Y21786.09 and X23086.72 is to be occupied. The azimuth mark bears N 21° 10’ 03” E. What clockwise angle must be turned to pass through a second station whose coordinates are Y22243.91 and X23948.00?

    1. 25° 25’ 18”
    2. 40° 57’ 14”
    3. 40° 50’ 21”
    4. 48° 12’ 39”

12. 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 reading?

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

13. Drawing file names have two parts: the name and the ___

    1. file type name
    2. dwg
    3. extension
    4. filing

14. What is the ground area in acres if the scale of a map is 1” = 200’ and the map area is equal to 13.351 square inches?

1. 12.26 acres
2. 12.25 acres
3. 12.65 acres
4. 13.65 acres

15. If the magnetic azimuth (from north) of a line is 135° 30’ in a location where the magnetic declination is 12° E, what is the true azimuth of the line?

    1. S 44° 30’ E
    2. 56° 30’
    3. 147° 30’
    4. 123° 30’

16. 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

17. 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

18. 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
    5.

19. Taping a distance of 967.82 feet was measured with a 100-foot steel tape that was 0.03 of a foot too long. What is the true distance measured (in feet)?

1. 967.53
2. 968.11
3. 967.84
4. 968.53

Control Points - Horizontal & Vertical

20. 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

21. In topographic surveying the control for elevations is called:

    1. positional
    2. horizontal
    3. vertical
    4. topographic

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

    1. each time used by closing the level circuit back on to it
    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

Field Operations

23. At a corner, the deed calls for a pine tree. In close proximity, you find a concrete monument, an iron pipe, and an oak stump with a blaze on it. What should you locate and record in the data collector?

    1. only the concrete monument is likely correct
    2. only the iron pipe as it matches the call distance
    3. only the oak tree as the original surveyor may not have indentified the tree
    4. everything as a registered professional will need to evaluate each item

24. 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

25. When running a 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

26. A 2-minute error in reading an angle means that a point that is set 50 feet away is off by :

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

27. Which of the following is a mistake and not an error?

    1. discrepancy in angle read on an instrument that is out of adjustment
    2. instrument set up on the wrong hub
    3. discrepancy in rod reading due to parallax
    4. slightly misreading the vernier

28. In measuring a zenith angle with a total station the following readings were observed:

    1D = 91° 14’ 26”
    2D = 91° 14’ 25”
    1R = 268° 45’ 28”
    2R = 268° 45’ 31”

    What is the best value for the zenith angle?

    1. 91° 14’ 26”

2. 91° 14’ 27”
3. 91° 14’ 28”
4. 91° 14’ 29”

29. To set a grade at a sewer line at station 13+50 (invert = 663.80) a level is set up and reads 5.03 on a benchmark (elevation of 672.55). What reading on a level Rod must be made to mark Cut 12’ (feet) on the grade stake?

    1. 1.78
    2. 2.93
    3. 5.03
    4. 3.85

30. 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”

Field Notes

31. 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 elevation of the ceiling of the box?

    1. 3687.68
    2. 3690.32
    3. 3674.32
    4. 3677.04

32. 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

33. A field crew equipped with a hand level and a range pole are to determine the rough elevation of an exploratory boring relative to a manhole rim (assumed elevation = 100 feet). What is the elevation of the boring in Feet? The following summarizes their filed notes:

    Backsight on manhole is 4.5 feet
    Foresight to turning point is 8.3 feet
    Backsight to turning point 1 is 1.1 foot
    Foresight to boring is 10.3 feet

    1. 78
    2. 87
    3. 100
    4. 114

Plan Reading & Preparation

34. A polar planimeter is used to:

    1. determine contours on a map
    2. calculate area by tracing on the boundary on any area
    3. calculate distances on a map
    4. measure field distances

35. A detailed diagram of a roadway construction materials at 90° to the centerline is called a:

    1. ground cross section
    2. plan
    3. profile
    4. typical cross section

36. On a USGS 7 ½ minute quad map one of the coordinate systems shown are:

    1. Clark Ellipsoid Coordinates
    2. Earth-Centered X, Y, Z Coordinates
    3. Lambert Conformal Coordinates
    4. Universal Traverse Mercator Coordinates

37. On a map at a scale of 1" = 2000' and a contour interval of 20', what is the % of slope of a railroad map, which scales 2.67 inches between four contour lines?

    1. 3.0
    2. 1.5
    3. 2.7
    4. 1.1

38. 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

Principles of the Profession

39. What does the term "G.I.S." refer to in land surveying?

    1. Geographic Information Systems
    2. Geodetic Interpretation Systems
    3. Global Information Systems
    4. Geographic International Survey

40. Actions that relate to the public, clients and other surveyors would describe:

    1. surveying ethics
    2. surveying standards on how a survey is to be performed
    3. laws relating to licensure or registration
    4. penalties for improper practice

41. Whether private survey control data is included in the national system is determined by which of the following agencies or groups?

    1. Bureau of Land Management
    2. National Geodetic Survey
    3. National Geological Survey
    4. United States Geologic Survey

First Aid & Safety

42. Always treat injuries in the order of their importance. Which is the first problem you should treat?

    1. bleeding
    2. stoppage of breathing
    3. burns
    4. heat stroke

43. According to OSHA, what is the responsibility of the employer as far as first aid is concerned?

    1. an employee must have a valid certificate in first aid training
    2. notices concerning health and safety shall be posted
    3. the employer shall provide proper first aid equipment and training
    4. these are the employees responsibilities

44. When dealing with first aid what should be conspicuously posted in the field survey vehicle?

    1. latest list of survey firms in the area worked by the survey crew
    2. telephone numbers of physicians, hospitals, and ambulances in the area worked by the survey crew
    3. C.B. handles of all C.B. radio operators in the area worked by the survey crew
    4. telephone numbers of all survey crews working in the area

45. 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

CST LEVEL II SAMPLE TEST ANSWERS

1.) **#3 any point along a centerline measured from the point of the beginning** – from page 239 (station 2) & page 241 (stationing) of Definitions of Surveying & Associated Terms

"Definitions of Surveying & Associated Terms"
Revised Copyright 2005
American Congress on Surveying and Mapping in collaboration with the University of Maine

2.) **#2 660, 660 –** from the Bureau of Land Management (BLM) website http://www.blm.gov/cadastral/Manual/pdffiles/9600-5.pdf Land Description Diagram (examine chart/map of township layout)

3.) **#2 double centering a series of points to set the foresight** - from page 87 (double centering) of Definitions of Surveying & Associated Terms

"Definitions of Surveying & Associated Terms"
Revised Copyright 2005
America

4.) **#3 12 hours –** "Each satellite…rotates around the Earth in about 12 hours"

"Construction Surveying and Layout"
Copyright 2003
Wesley G. Crawford
Creative Construction Publishing, Inc
Chapter 9 Subtitle "GPS Field Procedure-Overview" from page 9-3n Congress on Surveying and Mapping in collaboration with the University of Maine

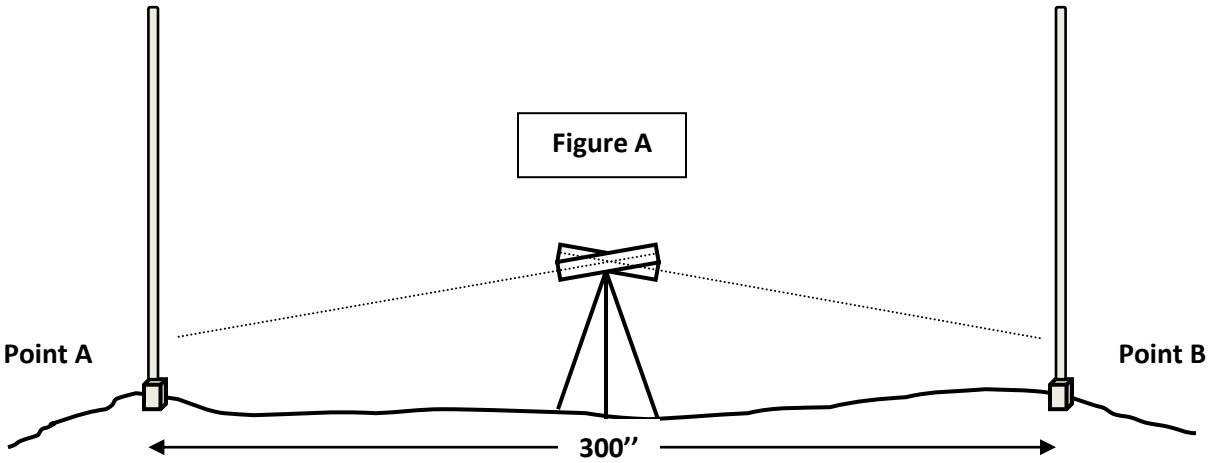
5.) **#2 33 feet long** - from page 122 (Gunter's Chain-pay attention to Early chains were 50 links, or 33 feet in length) &page 199 (pole 5) of Definitions of Surveying & Associated Terms

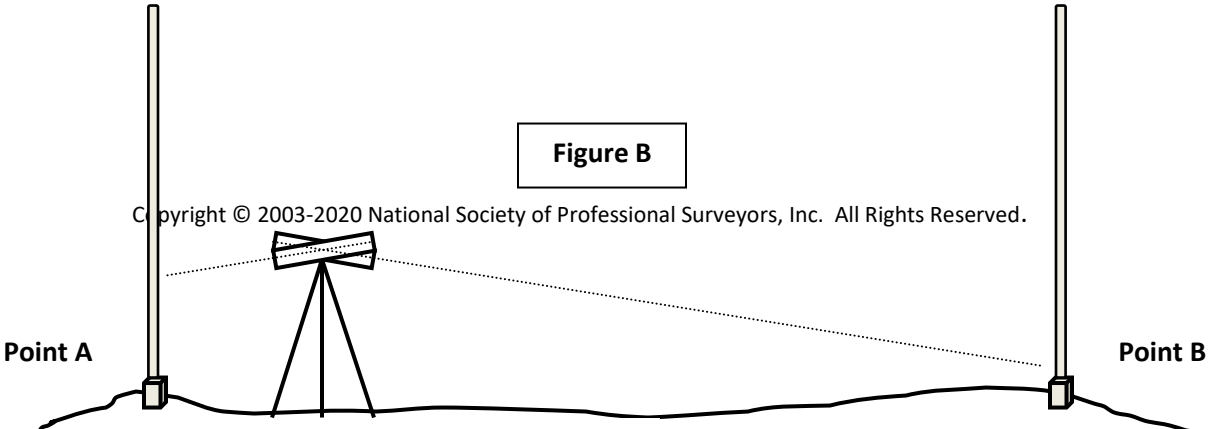
"Definitions of Surveying & Associated Terms"
Revised Copyright 2005

6.) **#4 temperature 30° above standard -** answers 1 through 3 would make the distance laid out "shorter" while the effect of temperature on a steel or nylon tape (30° above standardized temperature) will cause the metal or fabric to expand, thus making the tape longer. No calculation was needed to answer this problem just deductive reasoning.

"Survey Chaining Corrections" (Registration Number TXu 1-706-156)
Copyright 2010
James Girard Badinger Jr
Multiple Chapter references to all of these variances in Tape & Conditions

7.) **#1 the true difference between point A and B is 1.57…**even if the Level is out of center and needs adjustment the Level was placed between the two points at their mid-point so the error would be consistent in both directions. See Figure A & B below:





7.) Continued

(Figure A) The distance from Point A to Point B is 300' and the Level is setup at 150' between both Points (the Mid-point). If there is a "skew" of the Telescopic Lens (barrel) it will be evenly distributed on both Points since, it is at the Mid-point (**a good method to practice when running any level run**). **(Figure B)** However, when the level is placed at an unevenly distributed distance the "skew" of the Telescopic Lens becomes exaggerated on both points and the error becomes evident. Thus, the reason for placing the Level at the mid-point for the 1st comparison is to establish the best accurate determination of the difference between Point A & B. The 2nd comparison is to discover if the 1st comparison is valid or if the Level is in need of adjustment.

"Definitions of Surveying & Associated Terms"
Revised Copyright 2005
American Congress on Surveying and Mapping in collaboration with the University of Maine
Page 190 "peg adjustment"

From the Indiana Dept. of Transportation website:
http://www.in.gov/indot/files/proced1chapter2.pdf

8.) **#1 use light pressure when pushing tripod legs into the ground** - answers 2 through 4 are examples of what TO DO when setting up an instrument. Answer 1 clearly allows for the tripod legs to "move" or shift. Pressing the legs into the ground firmly will prohibit "sinking or settlement" of the tripod- experience/deductive reasoning.

9.) **#1 the axis of the level tube is perpendicular to the vertical axis** – if the bubble (spirit level) is centered the level tube (barrel-telescopic lens) is elongated toward the horizontal plane…and being level and centered over the horizontal plane or axis would make the tube perpendicular to the vertical axis or "at right angles to the plane of the horizon" from page 191 (perpendicular 2) of Definitions of Surveying & Associated Terms

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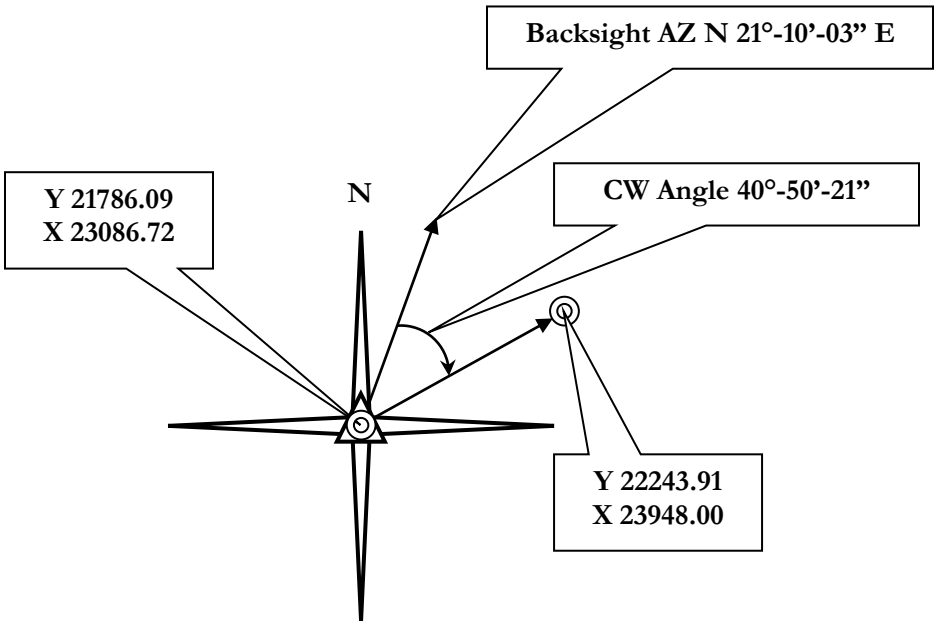
10.) **<u>#1 settlement of the tripod</u>…**answer 2 is an example of personal or accidental error; answers 3 & 4 are nominal/normal operating procedures or actions that take place around an instrument. Answer 1 is a common occurrence-especially, if an instrument is setup in soft earth or sits at a Control Point for an extended period of time-experience/deductive reasoning.

11.) **<u>#3 40°-50'-21"</u> (See Figure below with Explanation)**



Note: This question refers to the "Azimuth Mark Bears" and then gives the "Bearing" as N 21°-10'-03" E; this is not confuse the pupil as to the difference between an Azimuth and a Bearing but illustrates the need to understand the terminology of Surveying. A good reliable resource book to have is the Definitions of Surveying & Associated Terms.

First, find the difference between the point of origin's Azimuth Mark Bearing and the 2nd Station, which the Bearing computed, will help to ascertain the angle turned:

22243.91 – 21786.06 = 457.82 Difference between Y or "Northing"

23948.00 – 23086.72 = 861.28 Difference between X or "Easting"

Note that the coordinate values increase from the Origin Point (NGS Station) therefore the clockwise angle turned will be looking in the North East quadrant (algebraic assignment to direction discerning coordinate value changes… +N/+E = Northeast, +N/-E = Southeast, -N/-E = Southwest & -N/+E = Northwest). Take the Easting difference and divide by the Northing difference.

861.28 ÷ 457.82 = 1.881263379 (Tangent value of "new" Bearing to the 2nd Station)

11.) Continued

To find the Bearing (Azimuth) take this value and convert it to its Arctangent value; on most calculators, the 2nd function of TAN will do this (something to consider is being familiar with the functions of your calculator).

Arctangent of 1.881263379 = 62.00677874

This value is in Decimal Degrees format and needs to be converted to Degrees, Minutes and Seconds (look for the DD & DMS function keys on your calculator, again familiarity of how your calculator operates is important)

Decimal Degrees to Degrees, Minutes & Seconds of 62.00677874 = 62°-00'-24.40"

The decimal leftover of 24.40 can be dropped (0.40") since the angles in the multiple selection answers are all in whole numbers with no decimals after the "seconds" section.

Next, take the two Bearings, convert to Decimal Degrees, and find the difference between them (subtraction)

62.00677874 – 21.1675 = 40.83927874; then convert to Degrees, Minutes & Seconds

40.83927874 = 40°-50'-21"

http://www.oregon.gov/ODOT/HWY/GEOMETRONICS/docs/BasicManual2000_02.pdf Chapter 7 Coordinates covers the basic math needed to find this answer. A Survey Computation Course offered at a College/University is a sound step in building a good surveying math background. Many examples can be found via the Internet and various books but there is no real substitute for a qualified course covering Basic Survey Computations (you can view the CST Program Book, which recommends a list of publications suggested by the NSPS at the website below)

http://www.nspsmo.org/_data/global/images/NSPS/pdf%20docs/CST%20Program%20Book%20November%202010.pdf (Bibliography & References)

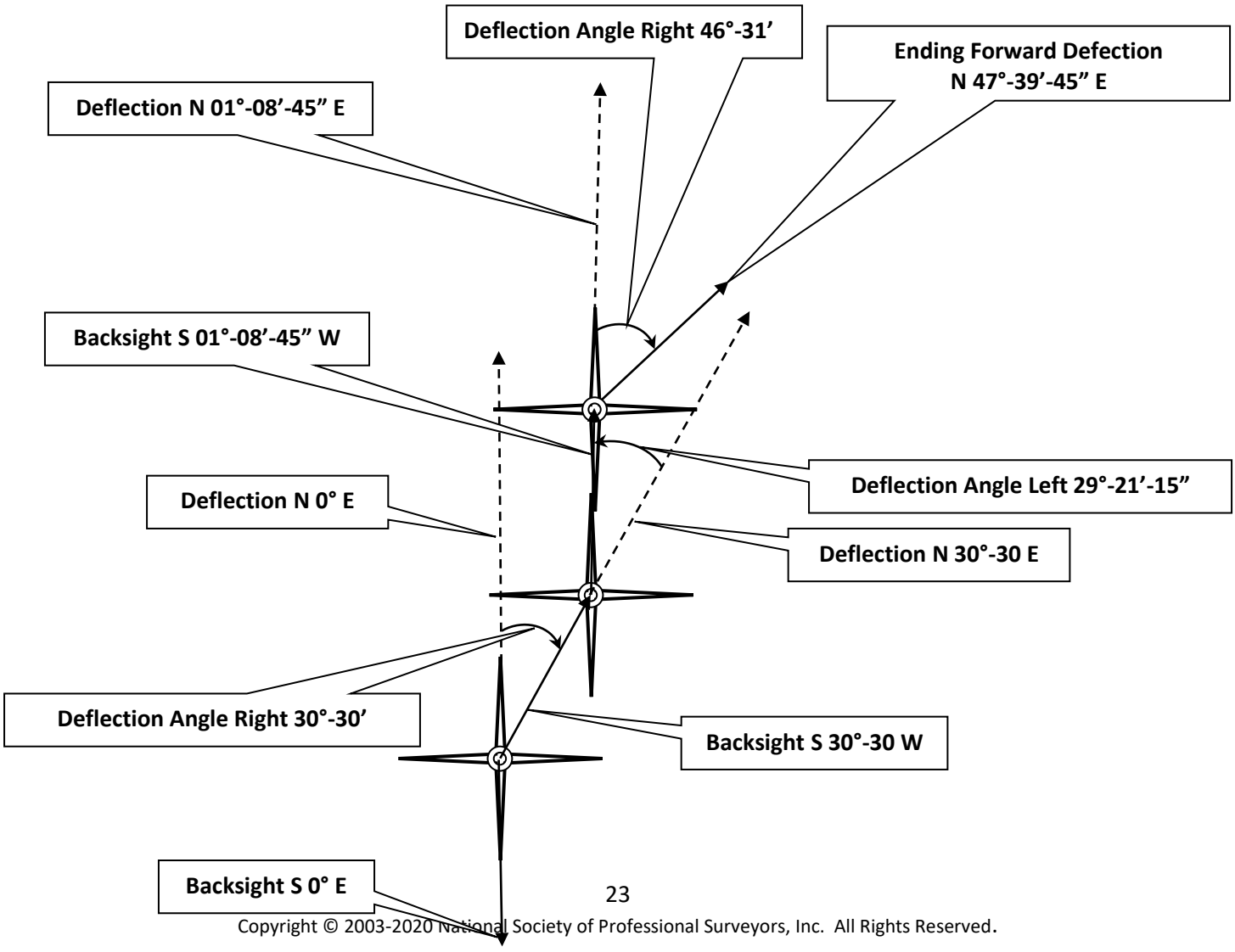
12.) **#3 N 47° 39’ 45” E** Note: In surveying, a horizontal angle measured from prolongation of the preceding “line of sight” to the next line; recorded as “right” (positive) if clockwise rotation and “left” (negative) if counterclockwise. Adding these angles up using their respective algebraic signs (+ 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)

13.) **#3 extension** – from the Wikipedia website…http://en.wikipedia.org/wiki/Filename..."Many operating systems, including MS-DOS, Microsoft Windows, and VMS systems, allow a filename extension that consists of one or more characters following the last period in the filename, thus dividing the filename into two parts: the basename[citation needed] (the primary filename) and the extension (usually indicating the file type associated with a certain file format)". The extensions used mostly In surveying the drawings are usually .dwg (AutoCAD) or .dgn (Microstation) but not limited to these. Occasionally a file such as .dxf is used.

14.) **#1 12.26 acres** Map Scale is 1 Inch = 200' and this refers to a measurement of area so every 1 Square Inch = 40000' Square. Multiply 1 Square Inch by 13.351

$200^2 \times 13.351 = 534040'$

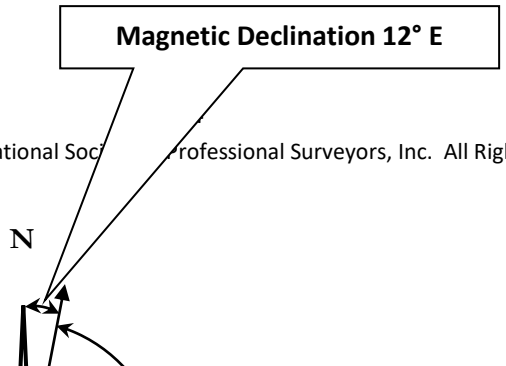
Next, divide 534040 by the value of a Square Acre (43560')

$534040 \div 43560 = 12.25987144$

Lastly, round off to a logical value best represented as one of the multiple choices 12.26 acres

A good understanding of Topographic, Mapping, and Measurement Conversion is needed to perform this type of computation. 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.

15.) **#3 147°-30' (See Figure Below)**



15.) Continued

In this case adding the Declination East to the Magnetic AZ will give the "True Azimuth".

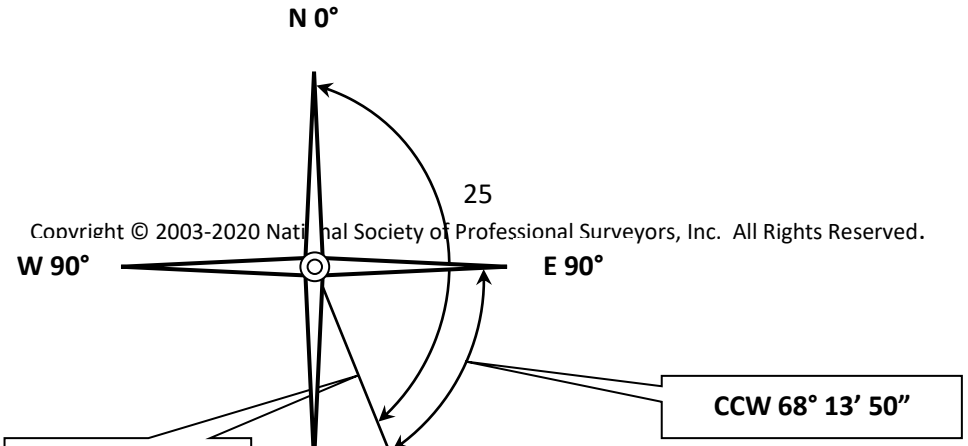
12° + 135°-30' = True AZ 147°-30'

From the National Oceanic and Atmospheric Administration website, (NGS Affiliated): http://www.ngdc.noaa.gov/geomag/faqgeom.shtml 5d. How do I correct my compass bearing to true bearing?

"Surveying Vol. 1"
16thEd. Copyright 2005
Dr. B.C. Punmia, Ashok K. Jain & Arun K. Jain
LAXMI Publications (P) Ltd.
Chapter 5 The Compass

"Elementary Surveying: An Introduction to Geomatics"
12th Ed. Copyright 2008
Charles D. Ghilani, Paul R. Wolf
Pearson Prentice Hall
Chapter 7 Angles, Azimuths & Bearings
(Sub Chapter 7.10 The Compass and the Earth's Magnetic Field)

16.) <u>#4 68° 13' 50" counter clockwise</u> (See Figure Below)



As the Figure shows, the Bearing is past Due East and its numeric value is decreasing as it is nearing Due South (Zero Degrees South). Therefore, the easiest way to achieve Due East is to turn a Counter-Clockwise Angle (CCW). This means that the difference between the current

16.) Continued

Bearing and Due East must be calculated. Subtracting the current Bearing from Due East will compute the CCW Angle needed to do this. First convert angular measurements to Decimal Degrees

Decimal Degrees of 90° Due East = 90.000000000
Decimal Degrees of 21°-46'-10" = 21.76944444

Then subtract:

90.000000000 - 21.76944444 = 68.23055556

Then convert back to Degrees, Minutes & Seconds:

68.23055556 = 68°-13'-50"

"Textbook of Surveying"
C. Venkatramaiah
Universities Press (India) Ltd.
Copyright1996 (Distributed by Orient Longman Ltd.
Chapter 3 Angles, Bearings and Azimuths

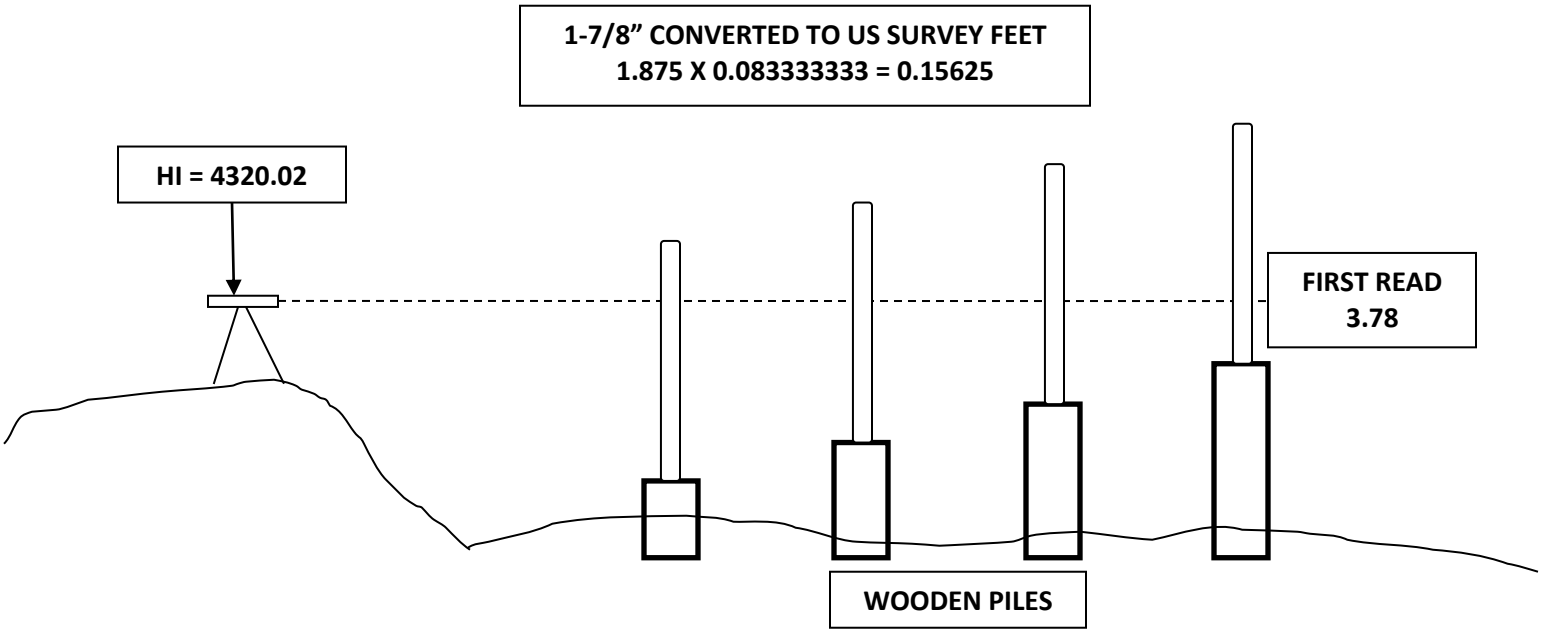
"Elementary Surveying: An Introduction to Geomatics"
12th Ed. Copyright 2008
Charles D. Ghilani, Paul R. Wolf
Pearson Prentice Hall
Chapter 7 Angles, Azimuths & Bearings

Below are some websites with related information:

http://www.ksls.com/forms/Converting%20between%20Azimuths%20and%20Bearings.pdf

http://www.biometrics.mtu.edu/fw2050/lectures/Lecture%209%20-%20Land%20Measurements%20and%20Map%20Use.pdf

17.) **<u>#3 4315.77</u> (See Figure Below)**



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.

18.) **#2 1:110,500** - Using the Formula for Error of Closure

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

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

$71392.06 \div 0.646374504 = 110449.9938$ 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

19.) **#2 968.11** - Non-Standard Chain/Tape Length Correction

$CL = (TL - SL) \times (L \div SL)$ Then; $CD = L + CL$

L = Measured Length
TL = True Length of Tape
SL = Standardized Length of Tape
CL = Correction Length Adjustment
CD = Corrected Distance

$CL = (100.03 - 100.00) \times (967.82 \div 100.00)$ Then; $CD = L + CL$

$CL = (0.03) \times (9.6782) = 0.290346$ Then; $CD = L + CL$

$CD = 967.82 + 0.290346$; CD = 968.110346 (968.11)

"Survey Chaining Corrections" (Registration Number TXu 1-706-156)
Copyright 2010
James Girard Badinger Jr
Non-Standard Length Correction Page 41

20.) **#3 NAVD Datum of 1988 (North American Vertical Datum of 1988)** – from the NGS/NOAA website under the FAQS section (Datums) https://www.ngs.noaa.gov/datums/faq.shtml & from page 76 (Datum, North American Vertical, 1988) of Definitions of Surveying & Associated Terms

"Definitions of Surveying & Associated Terms"

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21.) **#3 vertical** - from page 58 (control, vertical) & page 91 (elevation) of Definitions of Surveying & Associated Terms

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22.) **#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

23.) **#4 everything as a registered professional will need to evaluate each item –** A registered/licensed Surveyor is the only one who can verify the validity of a Boundary by means of methods, procedures, standards of practice, mathematics, and law. Only a registered/licensed Surveyor approved by the State in which they are registered/licensed may "sign" and approve the "field work" that is performed. Therefore, it is vital that anything that may convey, right-of-way, line of possession, property evidence, or encroachment should be located so that they can assess each entity and its value or significance of importance. The field crew should never neglect anything that is probable even if later turns out to be nothing of concern that is the task of the Licensed/Registered Professional Surveyor- experience/deductive reasoning. (Survey Law Classes & Minimum Standards of Surveying)

24.) **#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.

25.) **#1 the deflection angle for the previous station sighted on the circle-** Deflection Angle Methods vary from plunging/flopping the scope to sighting with Zero angle or Loading the angle for the Point Previous sat on or one that has better visibility. Below are Textbook explanations of these procedures.

"Elementary Surveying: An Introduction to Geomatics"
12th Ed. Copyright 2008
Charles D. Ghilani, Paul R. Wolf
Pearson Prentice Hall
Chapter 24 Horizontal Curves Page 703

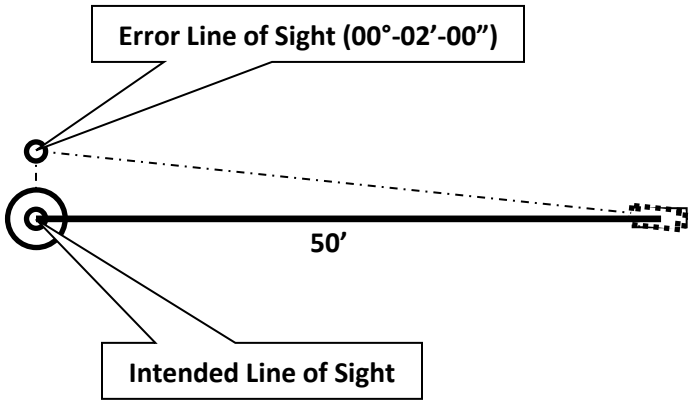
"Construction Surveying and Layout"
Copyright 2003
By Wesley G. Crawford
Chapter 16 Horizontal Curves Subsections 16-4 "Deflection & Chords" and 16-35 "Moving Up"

Below are some websites with related information:

http://www.esf.edu/for/germain/Horizontal%20Curve%20Formulae.pdf

http://ce113.groups.et.byu.net/other/Lab%209.pdf

26.) **#3 0.03 (See Figure Below)**



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)

26.) Continued

MULTIPLY $0.000581776 \times 50 = 0.029088819$

0.029088819 is 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

27.) <u>#2 instrument set up on the wrong hub</u> – answers 1, 3, & 4 are examples of accidental, random, or personal error which generally does not occur frequently or leads to small or negligible inaccuracies. Answer #2 clearly shows that attention was not given to where the surveyor was supposed to be…this is a blunder not an insignificant error that will affect a great part of the work performed from that point thus creating more problems (from page 34 (blunder-A mistake) & pages 99-100 (accidental, personal & random) of Definitions of Surveying & Associated Terms

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28.) <u>#3 91° 14' 28"</u>

CONVERT 91°-14'-26" TO DECIMAL DEGREES (91.24055556)
CONVERT 91°-14'-25" TO DECIMAL DEGREES (91.24027778)
CONVERT 268°-45'-28" TO DECIMAL DEGREES (268.7577778)
CONVERT 268°-45'-31" TO DECIMAL DEGREES (268.7586111)
SUBTRACT THE LAST 2 ANGLES FROM 360 TO FIND THE "DIRECT" VERTICAL ANGLE
360 - 268.7577778 = 91.24222222
360 - 268.7586111 = 91.24138889
ADD THE ANGLES TOGETHER
$91.24055556 + 91.24027778 + 91.24222222 + 91.24138889 = 364.9644444$
DIVIDE THE SUM OF THE ZENITH ANGLES BY THE NUMBER OF ANGLES TURNED/RECORDED
$364.9644444 \div 4 = 91.24111111$

CONVERT 91.24111111 TO DEGREES (91°-14’-28”)

"Schaum's Outline of Theory and Problems of Introductory Surveying"
28.) Continued
Copyright 1985
By James R. Wirshing, Roy H. Wirshing
McGraw-Hill Companies, Inc.
Chapter 6 Angle Measurement "6.3 Measuring Angles by Repetition" Page 121

29.) **#1 1.78** **-** 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			**- 12.00**	
ROD READ NEEDED			**= 1.78**	

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

30.) **#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:

30.) Continued

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

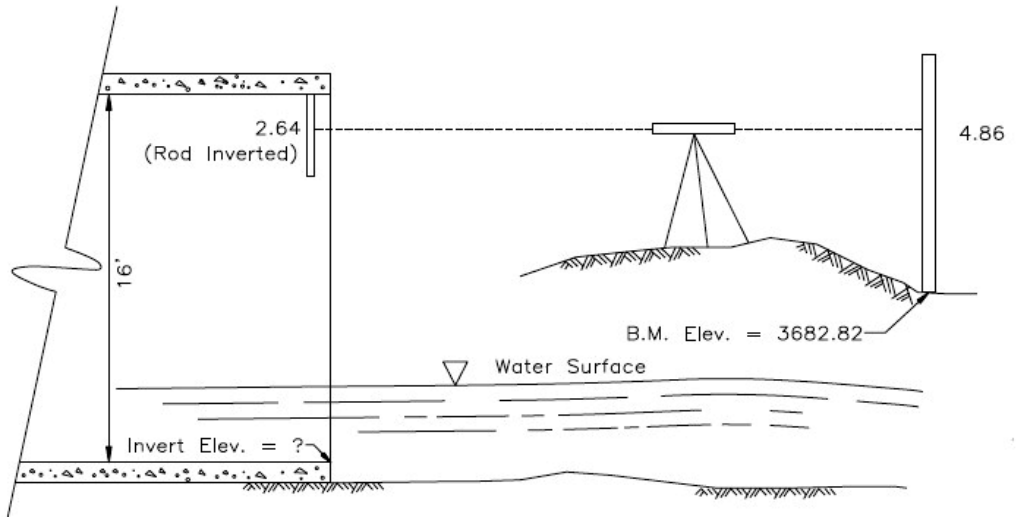
31.) **#2 3690.32** - Level Run Reading, Recording, and Computation are involved with this problem (Note that the rod read on the ceiling of the Structure is inverted. A normal rod read in this case would have been to record a Frontsight shot as a Minus or a value to be subtracted. Since this is not 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**

31.) Continued

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

32.) #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

33.) #2 87

STA	+	HI	-	ELEVATION
MH RIM	4.50	104.50		100.00
TP-1			8.30	96.20
" "	1.1	97.30		
BORING			10.3	87.00

Again, reducing notes will give the answer needed and the previous mention references from Problems #31 & #32 are applicable for this problem.

34.) #2 calculate area by tracing on the boundary on any area - from page 195 (planimeter, polar) of Definitions of Surveying & Associated Terms

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35.) **#4 typical cross section -** a combination from page 68 (cross-section) of Definitions of Surveying & Associated Terms and experience reading plans (typical cross-section of a road design)

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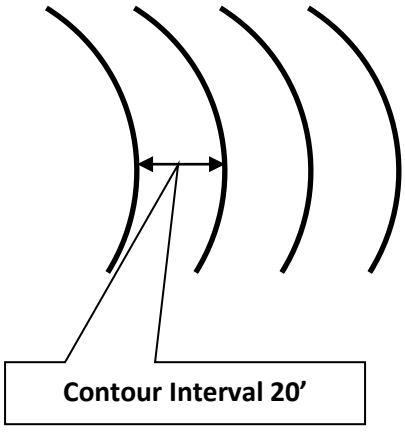
36.) #4 Universal Traverse Mercator Coordinates - from the website USGS-Questions and Answers About GPS
http://education.usgs.gov/common/lessons/gps_questions_and_answers.html

this whole webpage explains the use of the UTM coordinate system by the USGS and their quadrangle maps-research and experience

37.) **#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:

$3 \times 20 = 60$

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:

$60 \div 5340 = 0.011235955$

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

37.) Continued

$0.011235955 \times 100 = 1.123595505\%$

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

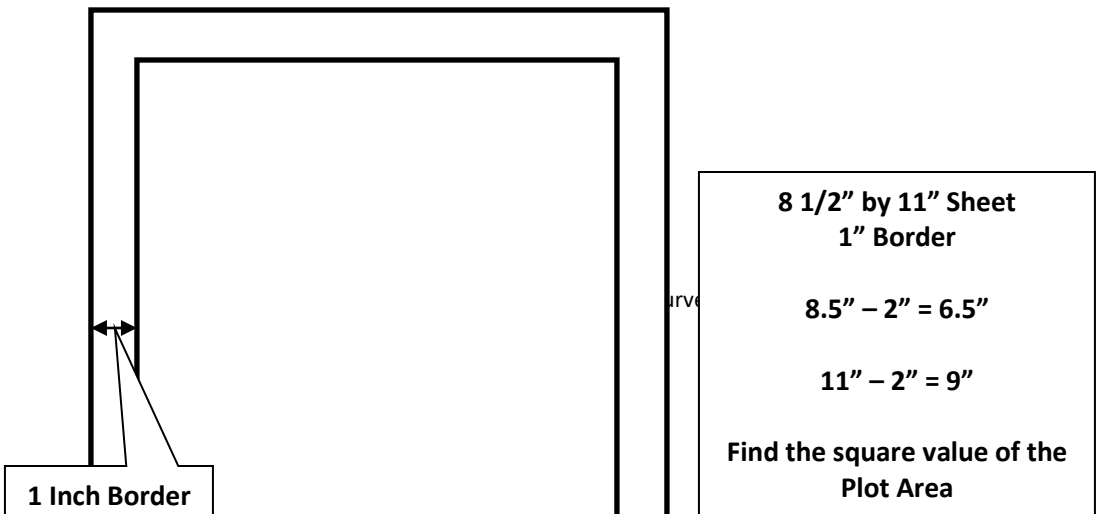
38.) **<u>#2 932</u>** - What was done for problem #37 (Ratio, Proportion & Percent) is essentially the same requirements needed to figure this problem. First, the scale here is not inches but 1’ is equal to 10,000’ but the paper is in Inches so a conversion is needed. One foot is equal to 12” and now a relationship can be found by dividing 10,000 by 12:

$10000 \times 12 = 833.333333333$

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

$833.333333333^2 = 694444.444443888$

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)



38.) Continued

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

694444.444443888 × 58.5 = 40624999.9999675

Now convert to Acres (43560) by dividing:

40624999.9999675 ÷ 43560 =932.621671257

Round off to 932 Acres the best answer offered.

39.) **#1 Geographic Information Systems** - from page 116 of Definitions of Surveying & Associated Terms

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40.) **#2 surveying standards on how a survey is to be performed.** - Minimum Standards or Standards in general are the procedures and methods on how a Survey should be conducted. These "standards" are designed to minimize errors and protect the public so that a "sound" Survey was performed that any Surveyor would have done in a like and similar circumstance.

Examples from the Internet:

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

NSPS http://www.true-north-surveying-mapping.com/wp-content/uploads/2010/04/NSPS-Standards-Topographic-Surveys.pdf

New York http://www.op.nysed.gov/prof/pels/lsurvguide.htm

Federal Geodetic Control Committee http://www.ngs.noaa.gov/FGCS/tech_pub/1984-stds-specs-geodetic-control-networks.htm

41.) **#2 National Geodetic Survey** – from the website National Geodetic Survey: What We Do http://www.ngs.noaa.gov/INFO/WhatWeDo.html & from page 175 of Definitions of Surveying & Associated Terms

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42.) **#2 stoppage of breathing** – from website Wikipedia about Cardiopulmonary Resuscitation http://en.wikipedia.org/wiki/Cardiopulmonary_resuscitation... "Chance of receiving CPR in time"… CPR is only likely to be effective if commenced within 6 minutes after the blood flow stops,[47] because permanent brain cell damage occurs when fresh blood infuses the cells after that time, since the cells of the brain become dormant in as little as 4–6 minutes in an oxygen deprived environment and the cells are unable to survive the reintroduction of oxygen in a traditional resuscitation. Research using cardioplegic blood infusion resulted in a 79.4% survival rate with cardiac arrest intervals of 72±43 minutes, traditional methods achieve a 15% survival rate in this scenario, by comparison. New research is currently needed to determine what role CPR, electroshock, and new advanced gradual resuscitation techniques will have with this new knowledge[48]…answers 1, 3, and 4 all are "treatable symptoms" that carry less weight concerning with matters of triage (the process of determining the priority of patients' treatments based on the severity of their condition)- research, experience and logical deduction.

43.) **#3 the employer shall provide proper first aid equipment and training** – from the OSHA website http://www.osha.gov/Publications/OSHA3317first-aid.pdf

44.) **#2 telephone numbers of physicians, hospitals, and ambulances in the area worked by the survey crew** – answers 1, 3, & 4 are of little or no help; having the numbers of the physicians, hospitals, and ambulances in the immediate area would give access to the proper and fastest way to deal with a medical emergency-research, experience and logical deduction

45.) **#4** **apply direct pressure and transport victim to medical attention immediately, watch for signs of shock** – from the website Red Cross Instructors Corner https://www.instructorscorner.org/ViewDocument.aspx?DocumentId=2271 under the heading "Injury Emergencies-Bleeding"- research, experience and training