USAID | LIBERIA
FROM THE AMERICAN PEOPLE

MILLENNIUM CHALLENGE CORPORATION
UNITED STATES OF AMERICA

LAND POLICY AND INSTITUTIONAL SUPPORT (LPIS) PROJECT

LAND SURVEYING TECHNICIAN COURSE: A THREE MONTH COURSE OF INSTRUCTION

DECEMBER 2012

This publication was produced for review by the United States Agency for International Development.

Prepared for Tetra Tech ARD by Manatron, Inc.–A Thomson Reuters Business, by Stephen Calder.

Prepared for United States Agency for International Development, USAID Contract Number EPP-I-00-06-00008-00, Task Order 2, Property Rights and Resource Governance (PRRG), Activity Task 6.5, Liberia Land Policy and Institutional Support Project

Tetra Tech ARD Principal Contacts: Maria Echievarria
Assistant Project Manager
Tetra Tech ARD
Burlington, Vermont
Tel.: 802-658-3890
Maria. Echevarria@tetratech.com

Megan Huth
Senior Technical Advisor/Manager
Tetra Tech ARD
Burlington, Vermont
Tel.: 802-658-3890
Megan.Huth@tetratech.com

LIBERIA LAND POLICY AND INSTITUTIONAL SUPPORT (LPIS) PROJECT

LAND SURVEYING TECHNICIAN COURSE: A THREE MONTH COURSE OF INSTRUCTION

DECEMBER 2012

TABLE OF CONTENTS

TABLE OF FIGURES

COURSE SUMMARY

For the proposed Land Surveying Technician Course, a three month course of instruction is offered in the discipline of land surveying. This course is designed to enable a student to go from having very little background knowledge of surveying to being able to plan and conduct a property boundary and topographic survey in the field, to process the field data, and finally to draw a map of the survey in CAD software.

The proposed course will focus on practical application. There will be some instruction in theoretical principles, but only as an aide to more competent execution of the components of a modern survey. It is envisioned that many of the work experiences of the instructor will be drawn upon to illustrate problems and solutions typically encountered in the modern workplace.

There are two main branches in the land surveying industry: property boundary surveying and topographic surveying to facilitate engineering design. This course evenly instructs in both arenas.

The course schedule is for a twelve week duration. There will be a class each weekday. In a typical week, Monday through Thursday are allotted for the presentation of new material. The fifth day is a review of the week's instruction.

There are field laboratory sessions given each Monday and Wednesday. These will be hands-on instructions with the survey equipment, and these sessions will take place out of doors. The field labs will consist of exercises that relate to the current classroom instructions.

A Computer Aided Drafting (CAD) laboratory is given each Tuesday and Thursday. These instructions will consist of small groups clustered around the computers with the students actually conducting and producing survey maps. Similar to the field lab, the CAD lab exercises will contemporaneously relate to and bolster the classroom instructions.

There will be two actual surveys conducted as class projects. The first will be a smaller property and the aim of the project will be to develop a technically acceptable and accurate survey map. The second survey project will undertake a larger property and will incorporate property boundary line determinations.

There will be quizzes and examinations given, and a grading system closely associated to university academics will be employed. However, the focus of the course will not be on the grades earned, but rather on the accumulation of practical and marketable skills.

The primary goal for the course is, upon completion, for the students to be able to initiate, conduct, and produce a small scale property boundary survey sufficient for the secure documentation of property boundary rights and or a topographic survey sufficient for engineering design.

COURSE SYLLABUS AND GRADING SCHEDULE

OBJECTIVE

This course is designed to enable a student to go from having very little background knowledge of surveying to being able to plan and conduct a property boundary and topographic survey in the field and to process the field data and finally to draw a map of the survey in CAD software.

ATTENDANCE AND PARTICIPATION

Both attendance and participation are mandatory and will be documented for each class day.

OFFICE HOURS

The instructor will be accessible for consultation, meetings, etc. Office hours and contact information are to be determined.

EXAMINATIONS

1. Two exams and four quizzes will be given as per the course curriculum and schedule.
2. Students must bring all that they need to exams. No borrowing will be allowed during exams.
3. Both the mid-term and the final exam will be comprehensive covering all course material to the particular point of the exam.
4. No make-up exams will be given for unexcused absences. If you miss a test without a verifiable excuse, you will receive a grade of zero for the missed test. If you missed an exam because of a verifiable excuse, the average of the other tests taken will be substituted for the missed test grade.
5. Students caught cheating on an exam, homework, or lab work will receive a grade of zero for that exam, homework, or lab work and further disciplinary action may be considered.
6. Work presentation and clarity are very important in surveying. Make sure that your work is presentable, easy to follow, and clear. Always show all steps of your solution. All work should be done in block lettering.

COURSE GRADING

Quizzes	15%
Mid-Term Exam	15%
Final Exam	30%
Land Survey Projects	30%
Attendance/Participation	10%
Total	100%

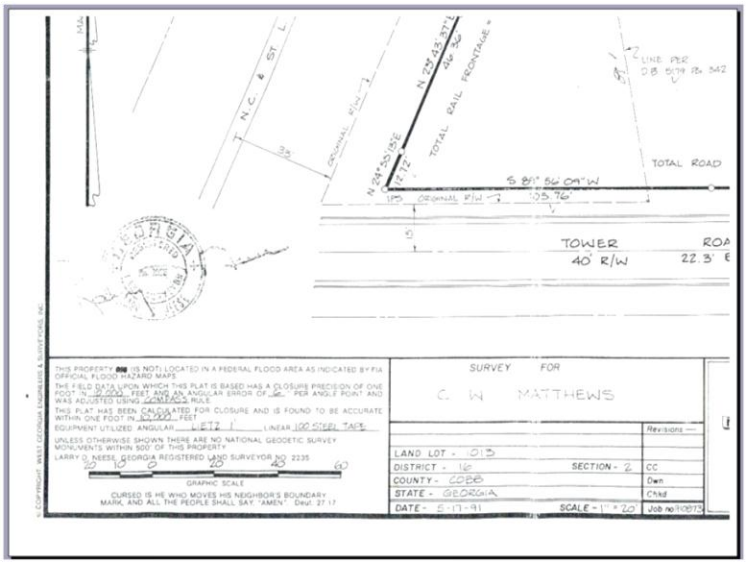
A	90-100
B	80-89
C	70-79
D	60-69

TEXT

All textbook and class resources will be provided by the instructor.

The students will need a blank paper notebook and writing instruments, an engineer's scale, and a drafting triangle. Students will also need to obtain a field book for the field exercises.

WEEK ONE: INTRODUCTIONS, SURVEYING THEORY, MEASUREMENT THEORY



1 Modern Survey with Historic Quotes

DAY 1

Introductions. Get names for everyone. Introduce myself and give a brief career summary.

Course Summary. Explain the goals of the course, discussion of the field exercises and the CAD lab exercises. Discuss class expectations, grading policies, office hours, contact information.

Land Surveying theory and history. The societal basis for surveying. The value we provide to and our role in modern society. Our role in historical society. Brief discussion of professionalism.

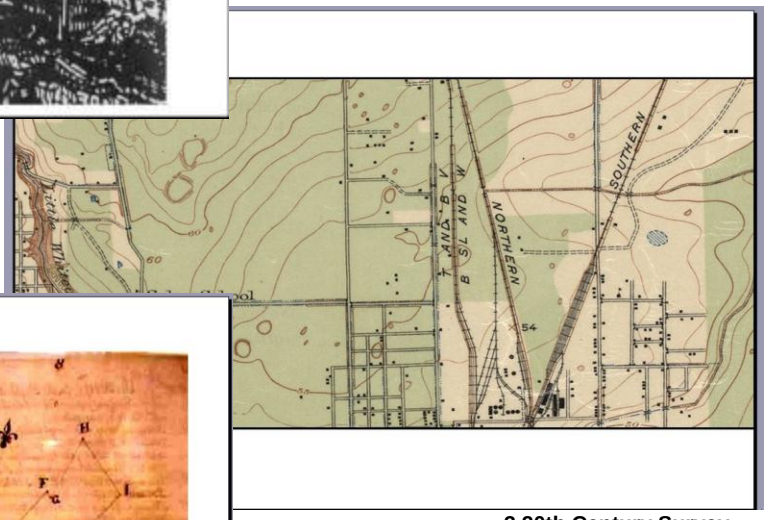
Historical Background

- Surveying's existence reaches back to civilization's earliest records.
- First registered county surveyor of the United States of America was George Washington. Culpepper County, Virginia, 1749.
- America's First Black Man of Science, Benjamin Banneker was a surveyor.

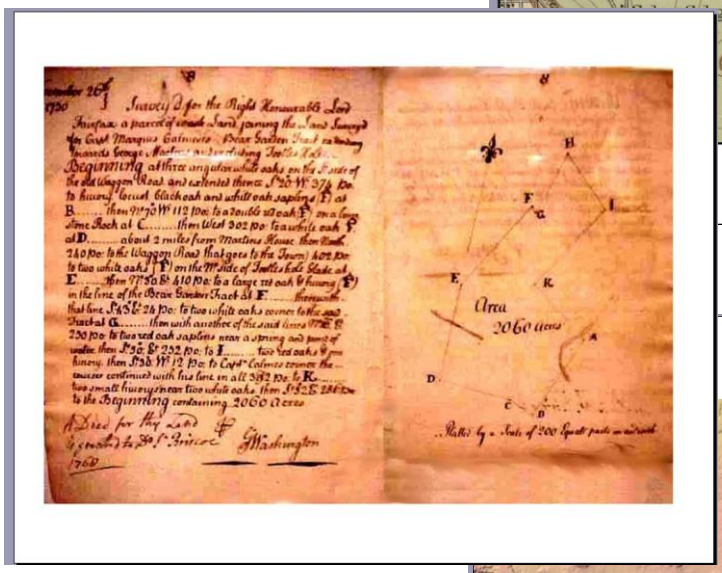
2 George Washington, Land Surveyor

Context in Society

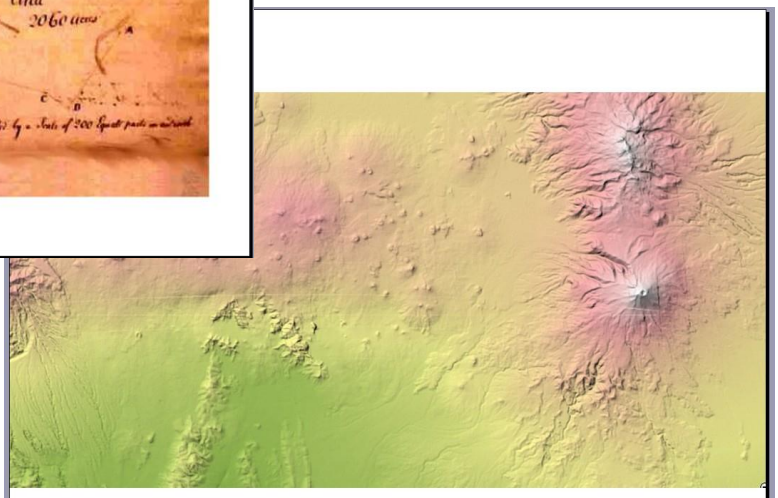
- Every map ever published owes part of its existence to a land surveyor. In the chain of development of maps, all are traced back to the work of a land surveyor.
- From this can be derived that ALL GEOGRAPHIC TRUTH IN THE WORLD ORIGINATES WITH THE WORK OF A LAND SURVEYOR.



3 20th Century Survey

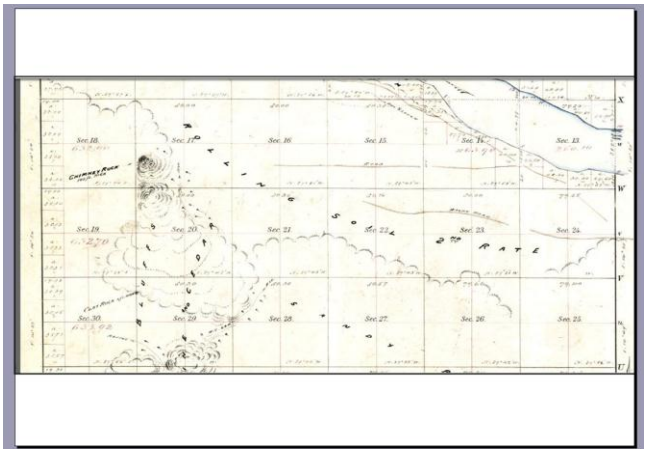


4 George Washington, Land Surveyor



5 21st Century Survey

+



6 19th Century Survey

Measurement Theory.

1. Counts vs. measures.
2. Significant digits.
3. Random and systematic errors.

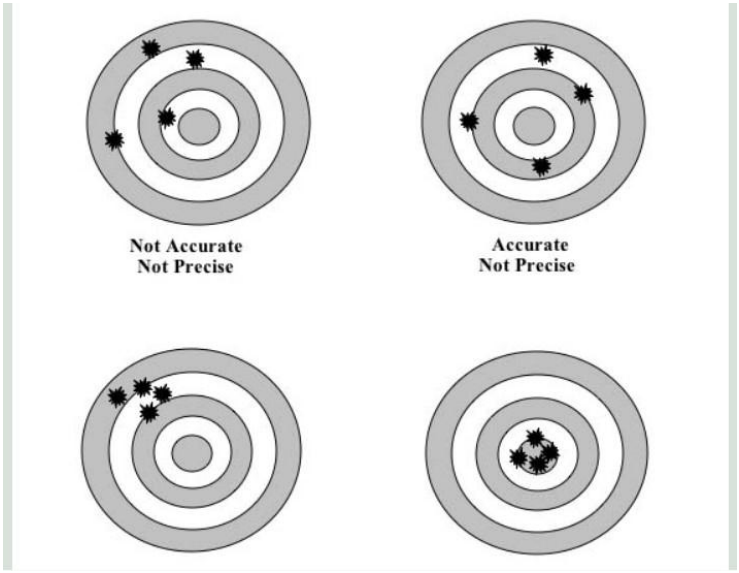
Field Ex. 1 Introduction to the field exercise process. Introduction to and demonstration of the equipment. Instruction in setting up the tripod.

Counts and Measures

- One basic way of classifying numbers that is often overlooked is dividing them into counts and measures.
- Counting = dealing with whole numbers only; there are no decimals.
- Always are exact.
- Measures can never be exact.
- Measures involve numbers after the decimal point.
- Measurements are never more than estimates of the true size of a quantity.
- Therefore, all we can obtain in measurement is not the true value, but the most probable value.

Accuracy and Precision

- Definitions.
- Characteristics of each.
- Accuracy is a synonym for truth. Precision equates to fineness of measurement or repeatability.
- Tell-tale elements of each in measurement results.



7 Accuracy & Precision Matrix

Error Types

1. Random
2. Systematic
3. Mistakes or blunders

Qualities of the three error types

1. Random Errors: caused by human and instrumental and environmental imperfections.
    - Example: mis-centering the transit over a point.
    - Tend to be small in magnitude.
    - Can occur in any direction, and thus tend to cancel out to a very small quantity.

2. Systematic Errors: follow some mathematical or physical law.
    - Example is mis-alignment of the level bubble on a prism pole.
    - Usually occur in one direction (i.e. with one algebraic sign) and thus the longer and more numerous the measurements the larger the error becomes.
3. Blunders and Mistakes:
    - Example: Transposing numbers or "dropping" a chain.

DAY 2

Measurement Theory continued. Error discussion continued. Common sources of errors encountered. Introduction to error propagation.

Discussion about the error matrix and the most and least desirable position in the matrix. Talk briefly about the four possible outcomes of the error matrix.

Final Thought:

Michigan Supreme Court Justice Thomas Cooley (1824-1898) on measurements from his treatise "The Judicial Function of Surveyors":

"When a man has had training in one of the exact sciences, where every problem within its purview is supposed to be susceptible of accurate solution, he is likely to be not a little impatient when he is told that, under some circumstances, he must recognize inaccuracies, and govern his action by facts which lead him away from the results which theoretically he ought to reach. Observation warrants us in saying that this remark may frequently be made of surveyors."

CAD Lab 1 Introduction to the CAD lab and the CAD program.

DAY 3

Distance Measuring. Pacing formula. Overview of pacing, chaining, taping, stadia, EDMs, laser scanning, laser tracking. Principles of accurate distance measurement.

Field Ex. 2 Performance of pacing courses. Three lengths; one short, one long, one on a hill.

Distance Measurement Hierarchy

- Pacing.
- Instrumental stadia.
- Chaining or taping.
- EDM from a total station.
- GPS
- Laser scanner (LiDAR)
- Laser tracker.

DAY 4

Distance Measuring continued. Exploration of the pacing course, including error analysis. In-depth discussion of total station distances. In-depth discussion of field notes. Examples of good field notes distributed.

Qualities of Distance Measurement

- Principle of error propagation.
- Principle of the expansion of scales of internal error throughout hierarchy.
- Prevalence of parallax at lower ends of heirarchy.
- Importance of separate cross-checking process.
- Principle of a long chain measuring short.

Procedure of Taping & Chaining

- Chain is unfurled and front chain person advances.
- Rear person aligns front person.
- Chain is held horizontal, with aid of plumb bob is needed.
- Rear person holds 0’ at control point and says “MARK”.
- Front person marks the ground at the 100’ point and says “CHECK”.
- Procedure is repeated for a check.
- Both persons advance to 100’ mark.

- On the last segment, rear chain person holds an even foot mark at the pin and front person holds graduated portion on the forward control point. Rear chain calls out the foot, the front chain calls out the tenth's and hundredth's. (the hundredths are estimated). The distance is recorded.

CAD Lab 2 Setting up the drawing space. Drawing the pacing exercise.

DAY 5

Weekly review. Recap of classroom, CAD lab, and field instructions.

Week Two Distance Measurement

DAY 6

Introduction to CAD. Discussion of the CAD lab and explanation of drawing exercises. AV demonstration. Survey drawing examples.

CAD Lab 2 assignment due.

Field Ex. 3 Total station demonstration, esp. EDM. Tripod setup continued.

CAD THEORY
- Fundamental differences between CAD and hand drafting.
- Strengths and weaknesses of CAD.
- Demonstration of a CAD drawing.

DAY 7

Distance measurement continued. Curvature and refraction. Thermal expansion of tapes.

CAD Lab 3 Review of drawing the pacing exercise.

Errors Normally Encountered in Taping
- Temperature. Ct = 0.00000645*(30°-68°)*675.48 = -0.17'
- Incorrect tape length. 662.35 + 6.6235*(0.02) = 662.48
- Combined. Ct = (0.00000645)(18°-68°)*1238.22

DAY 8

Distance measurement continued. Advanced distance measurement methods; laser scanning, laser tracking, GPS.

Field Ex. 4 Chaining or taping exercise.

DAY 9

Distance measurement completed. Final discussion for distance measurement.

CAD Lab 4 Drawing an averaged distance comparison exhibit.

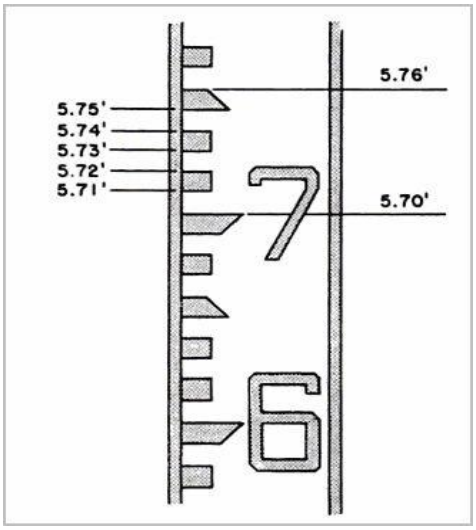
DAY 10

Weekly review. Recap of classroom, CAD lab, and field instructions.

Quiz 1

WEEK THREE VERTICAL MEASUREMENT

8 Philadelphia Pattern Leveling Rod



DAY 11

Vertical measurement. Introduction of principles of vertical measurement. Brief discussion of datums and benchmarks.

CAD Lab 4 assignment due.

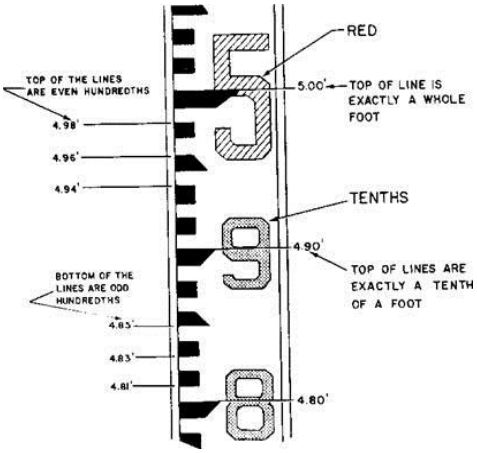
Field Ex. 5 Transferring elevations by leveling exercise

DAY 12

Vertical Measurement continued. Discussion of differential levels. Auto-level demonstration. Demonstration of differential level notes.

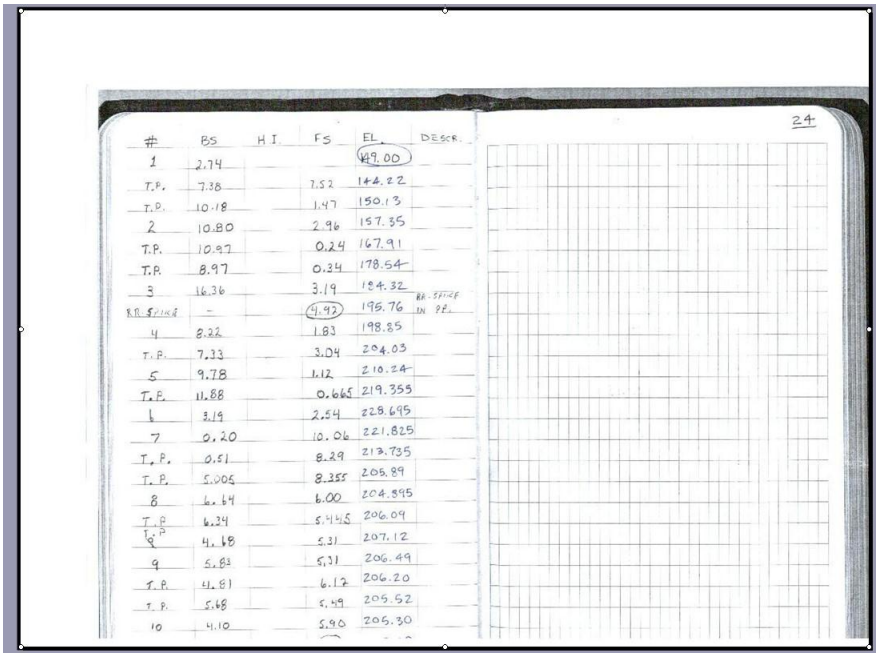
Levels

- Demonstration of the auto-level and exploration of associated errors.
- Basic premises of differential level measurement and transference of known elevations.
- Back sighting and forward sighting procedures.
- Philadelphia pattern leveling rods
- Automatic levels with pendulum assembly mounts.
- Elements of the Compensator.
- Curvature and Refraction.



9 Philadelphia Pattern Leveling Rod

CAD Lab 5 Drawing an elevation transferal exhibit.



#	BS	HI	FS	EL.	DESCR.
1	2.74			149.00	
T.P.	7.38		7.52	144.22	
T.P.	10.18		1.47	150.13	
2	10.80		2.96	157.35	
T.P.	10.97		0.24	167.91	
T.P.	8.97		0.34	178.54	
3	16.36		3.19	184.32	
RR SPIKE	–		4.92	196.76	RR SPIKE IN PP
4	8.22		1.83	198.85	
T.P.	7.33		3.04	204.03	
5	9.78		1.12	210.24	
T.P.	11.88		0.665	219.355	
6	3.19		2.54	228.695	
7	0.20		10.06	221.825	
T.P.	0.51		8.29	213.735	
T.P.	5.005		8.355	205.89	
8	6.64		6.00	204.895	
T.P.	6.34		5.445	206.09	
T.P.	4.68		5.31	207.12	
9	5.83		5.31	206.49	
T.P.	4.81		6.17	206.20	
T.P.	5.68		5.49	205.52	
10	4.10		5.90	205.30	

24

10 Differential Leveling Notes

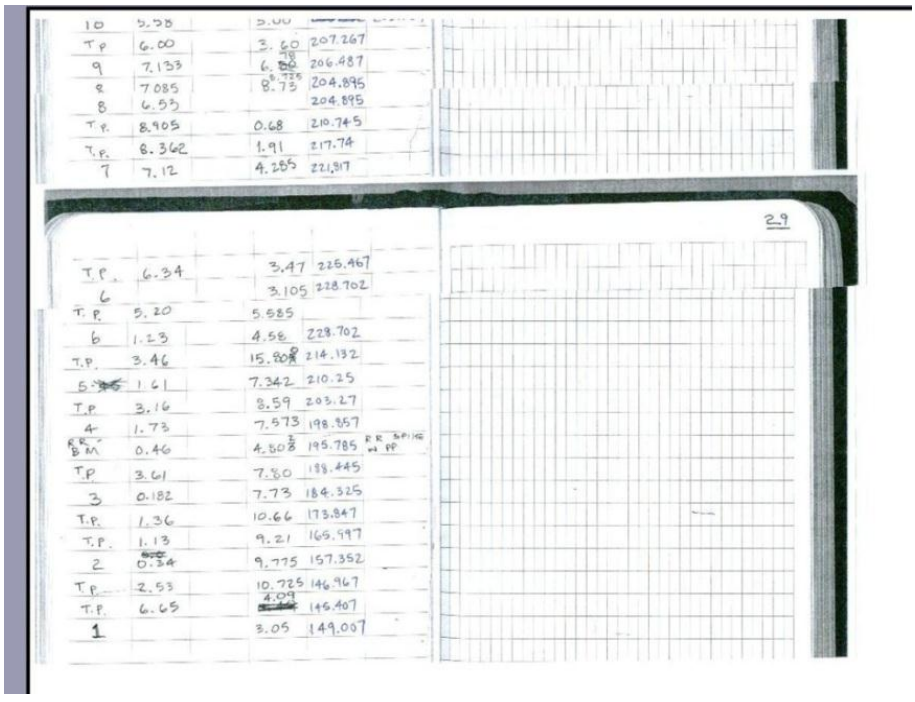
DAY 13

Vertical Measurement continued. Common sources of errors in leveling. In-depth exploration of differential leveling notes procedures.

Aspects of Good Leveling Procedure

- Abundance of benchmarking, preferably double run.
- Temporary benchmarks for provisional checks.
- Balancing forward and back sights.
- Example: Circuit of 7.2 miles with 0.007 mis-closure.

Field Ex. 6 Differential level circuit run with notes kept



10	5.70	3.60	207.267
TP	6.00	6.80	206.487
9	7.133	8.775	204.895
8	7.085		204.895
8	6.53		
T.P.	8.905	0.68	210.745
T.P.	8.362	1.91	217.74
7	7.12	4.285	221.917

T.P.	6.34	3.47	225.467
6		3.105	228.702
T.P.	5.20	5.585	
6	1.23	4.58	228.702
T.P.	3.46	15.808	214.132
5	1.61	7.342	210.25
T.P.	3.16	8.59	203.27
4	1.73	7.573	198.857
RR BM	0.46	4.808	195.785 RR SPIKE IN PP
TP	3.61	7.80	188.445
3	0.182	7.73	184.325
T.P.	1.36	10.66	173.847
T.P.	1.13	9.21	165.997
2	0.34	9.775	157.352
TP	2.53	10.725	146.967
T.P.	6.65	4.09	146.407
1		3.05	149.007

29

11 Differential Leveling Notes with Closure

DAY 14

Vertical measurement continued. Advanced sources of errors for level circuit. Introduction to adjusting a differential level ciruit. Benchmarking procedures.

CAD Lab 6 Production of a level circuit with benchmarks exhibit.

Differential Leveling Measurement Continued.

- The peg test.
- Inverted rods for obvert observations.
- Reciprocal leveling across rivers and ravines.

DAY 15

Weekly review. Recap of classroom, CAD lab, and field instructions.

WEEK FOUR VERTICAL AND ANGULAR MEASUREMENT AND COORDINATE GEOMETRY

DAY 16

Vertical measurement completed. Adjusting a differential level circuit.

CAD Lab 5 assignment due.

Field Ex. 7 Differential level circuits continued.

Curvature and Refraction

- C+R in feet = 0.574 * (distance in miles)^2.
- Standard C+R in 1,000'.
- Accounting for C+R in the field.
- Accounting for C+R digitally in the software.

DAY 17

Angular measurement. Introduction of systems and principles of angular measurement and directional systems.

CAD Lab 7 Production of a survey map showing control points and elevated benchmarks.

Angle Computations

- Sum of interior angles in a polygon = (n-2)*180
- Field operations with a transit or theodolite.
- Winding up angles for accumulated measurement.
- Doubling angles
- Prolonging a straight line.
- Direct and indirect angles
- Deflection angles.

DAY 18

Angular measurement continued. Explanation of theodolite procedures such as doubling angles and double centering for line prolongations.

Field Ex. 8 Turned angle exercises with the total station.

DAY 19

Angular measurement continued. Coordinate geometry. Explanation of coordinate systems and coordinate geometry. Calculations based on angular measurement. Computing distances from coordinate points. Discussion of the Pythagorean Theorem. Principles of running a closed survey traverse.

CAD Lab 8 Production of a simple survey control traverse drawing.

DAY 20

Weekly review. Recap of classroom, CAD lab, and field instructions.

Quiz 2

WEEK FIVE ANGULAR MEASUREMENT AND COMPUTATIONS

DAY 21

Coordinate geometry continued. Traverse calculations. Coordinate geometry calculations continued. Calculation of area for a polygon. Long- form traverse calculations with latitudes and departures.

CAD Lab 7 assignment due.

Field Ex. 9 A closed survey control traverse is run.

Traverse Computations for a closed polygon

- Compute the angular error and adjust the individual angles based on the misclosure of the sum from the closed polygon formula.
- Start at the angle just to the counterclockwise direction of the leg that has the azimuth.
- CounFor each station, add the interior angle to the back azimuth of the previous course. Add the interior angle to the back azimuth if you are going counterclockwise, subtract it if you proceed clockwise.
- To find the back azimuth of the previous course, if it is more than 180° subtract 180. If it is less than 180° add 180.
- Convert to bearings based on this rubric:

- In the NE quadrant: the bearing angle equals the azimuth. Just add the letters.
- SE: the azimuth is subtracted from 180°.
- SW: 180° is subtracted from the azimuth.
- NW: the azimuth is subtracted from 360°.

DAY 22

Traverse calculations continued. Computing the error of closure for a traverse. Sin and Cosine calculator functions.

CAD Lab 9 Drawing a simple survey.

DAY 23

Traverse calculations continued. Adjusting a closed traverse by means of latitudes and departures.

Field Ex. 10 Running a property boundary traverse with side shots to buildings and ordnance.

DAY 24

Traverse calculations continued. Computing the area of a traverse.

CAD Lab 10 Drawing a simple survey continued.

DAY 25

Weekly review. Recap of classroom, CAD lab, and field instructions.

WEEK SIX TRAVERSING, RESECTIONS, AND TOPOGRAPHIC MAPPING

DAY 26

Traverse calculations continued. Demonstration of resections and intersections.

CAD Lab 10 assignment due.

Field Ex. 11 Begin first survey project.

DAY 27

Angular measurement and traverse calculations completed. Completion of long-form traverse calculations.

CAD Lab 11 Drawing the traverses. Begin production of the first survey project drawing.

Curve Computations

- Geometrical elements of a curve.
- Degree vs. chord definition of curves.
- Computing angles to lay out points on a curve.
- Formulas for computing curve elements.

DAY 28

Topographic mapping. Manual contouring procedure. Survey examples.

Field Ex. 12 First survey project continues.

DAY 29

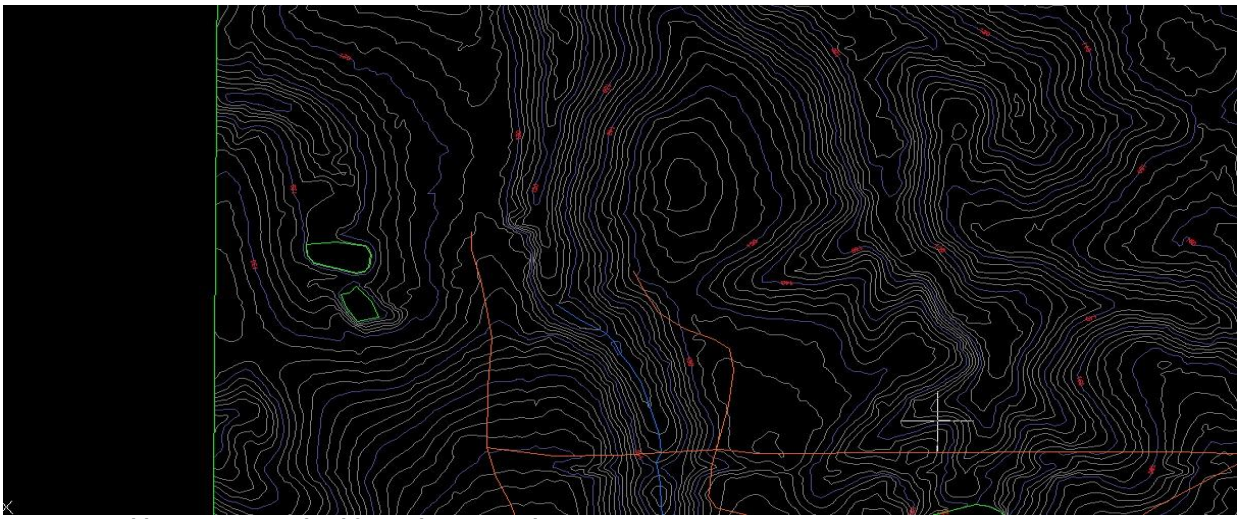
Topographic mapping continued. Manual production of a manual topographic survey.

CAD Lab 12 Contouring in CAD. Production of a topographic map. CAD work on the first survey project continues.

12 Topographic Contours Derived from Aerial Photography

Topographic Mapping

- Principles of contouring.
- Methodologies; cross sections, leveling grid, breaklines.
- Creating contours by hand drafting.
- Digitally created contours; DTMs; TIN.



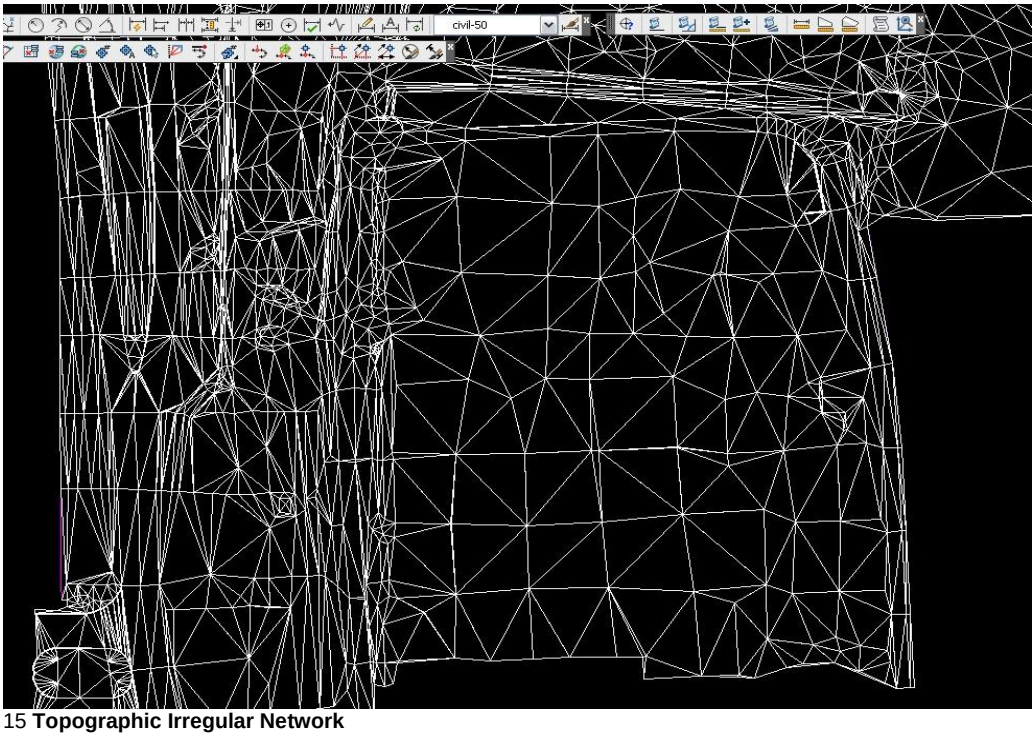
13 Topographic Contours Derived from LiDAR Mapping

14 Aerial Photo of Same area

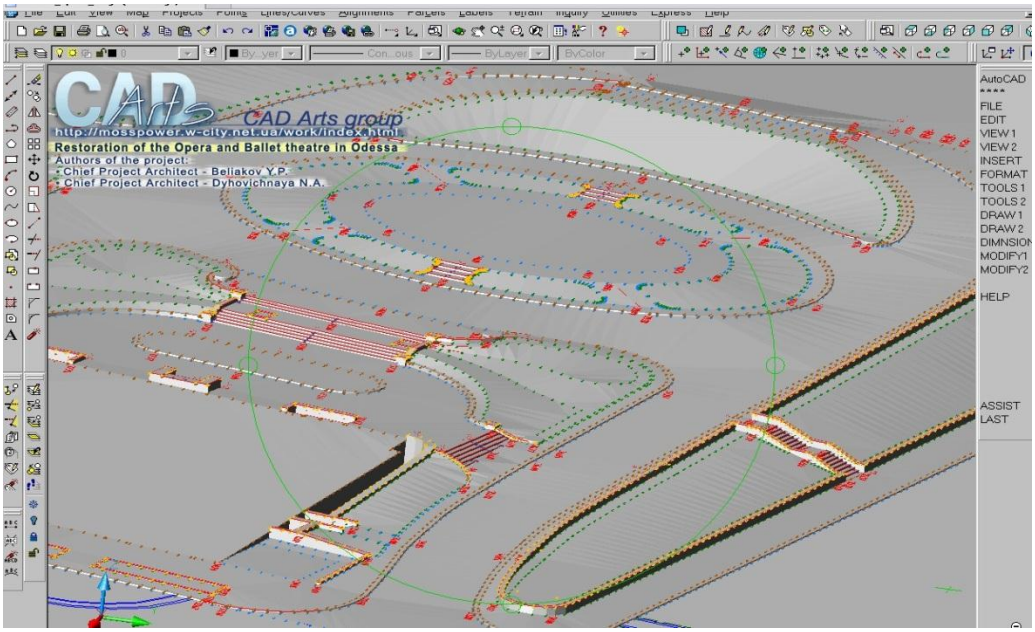
DAY 30

Weekly review. Recap of classroom, CAD lab, and field instructions.

Comprehensive mid-term examination



15 **Topographic Irregular Network**



16 Digital Terrain Model

WEEK SEVEN TOPOGRAPHIC MAPPING, CONTOURING

DAY 31

Advanced topographic concepts. Exploration of vertical datums and the geoid. The relationship between the geoid and ellipsoid. Computing grade. Delineating drainage basins.

CAD Lab 11 assignment due.

Field Ex. 13 Collecting ground shots on survey project for topography.

DAY 32

Advanced topography continued. Principles of topography in the digital realm. Ditigal terrain models. Establishing breaklines in the point data.

CAD Lab 13 Computing contours in CAD.

17 Found Government Monument

DAY 33

Topography completed. Production of contour maps.

Field Ex. 14 Work on first survey project continues.

DAY 34

Property boundary surveying. Principles of property boundary work.

CAD Lab 14 Production of a topographic map. Conclusion of office work for first survey project.

Property Boundary Surveying

- Exploration of the Doctrine of Monuments.
- Legal foundation for property boundary determination.
- "Show them what they own"; the foundation of property boundary surveying?
- "Dig, Measure, Judge, Communicate."
- Distinction between Adverse Possession and Acquiescence.
- Distinction between Original Surveys and Retracements.

19 Found Government Monument

DAY 35

Weekly review. Recap of classroom, CAD lab, and field instructions.

18 Found Government Monument

WEEK EIGHT GEOMETRIC COMPUTATIONS AND PROPERTY BOUNDARY PRINCIPLES

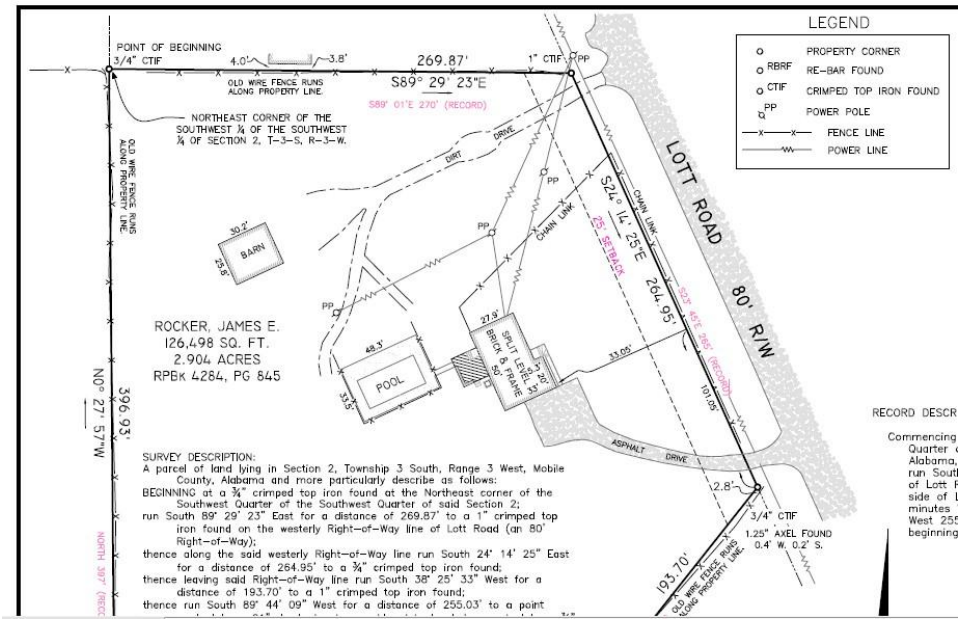
DAY 36

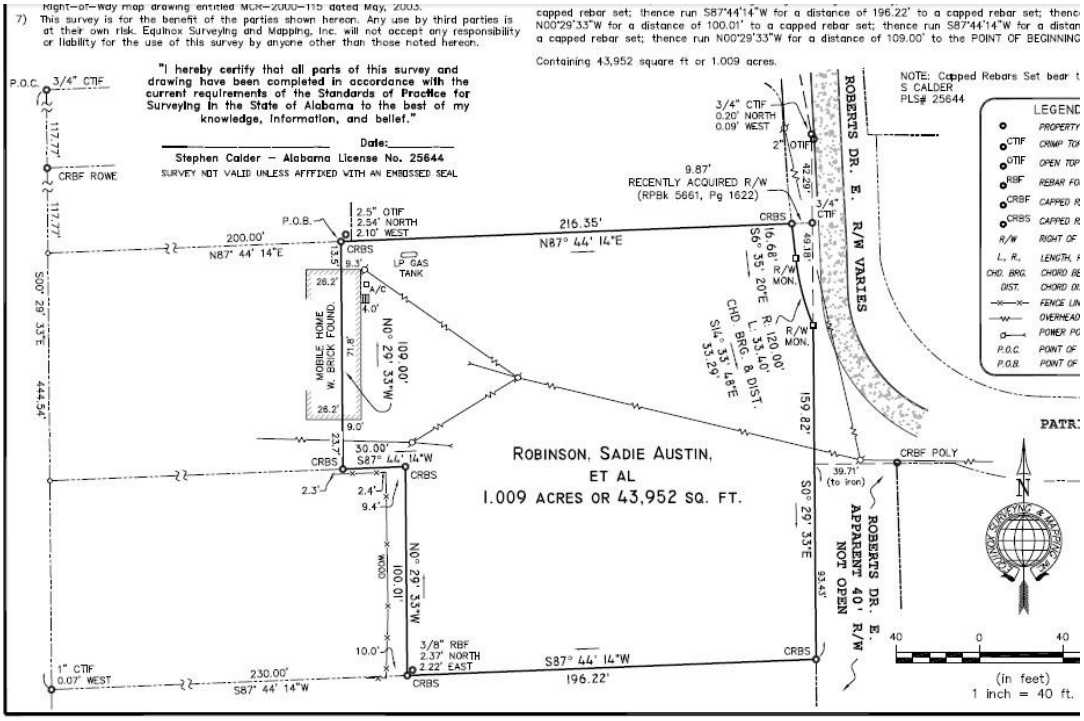
Property Boundary surveying continued. Role and tasks required of surveyors for property boundary work. Survey drawing examples.

CAD Lab 14 assignment due.

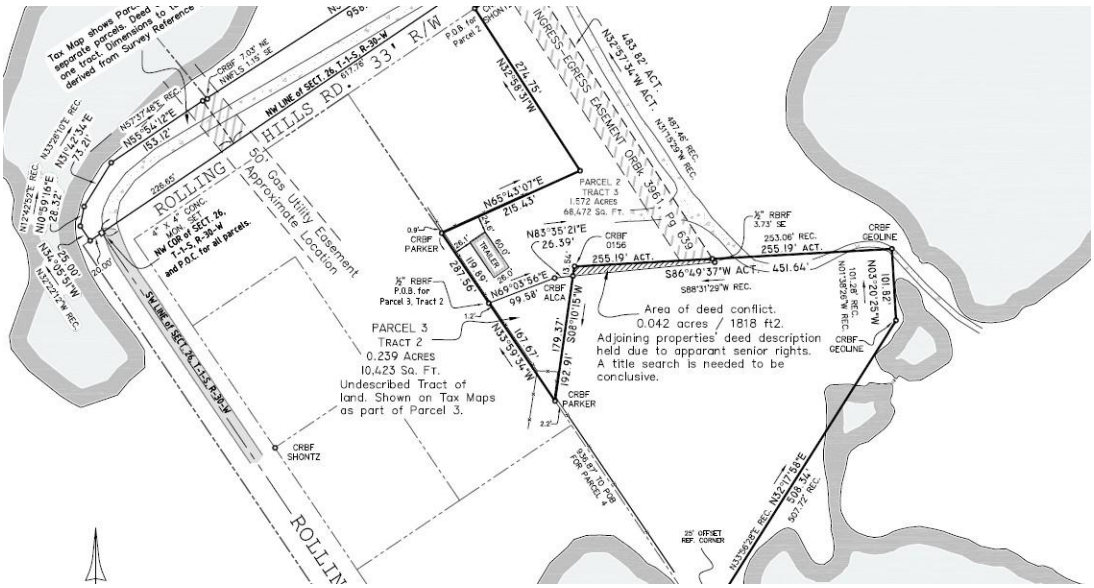
Field Ex. 15 Conclusion of field work for first survey project.

20 Property Boundary Survey Example

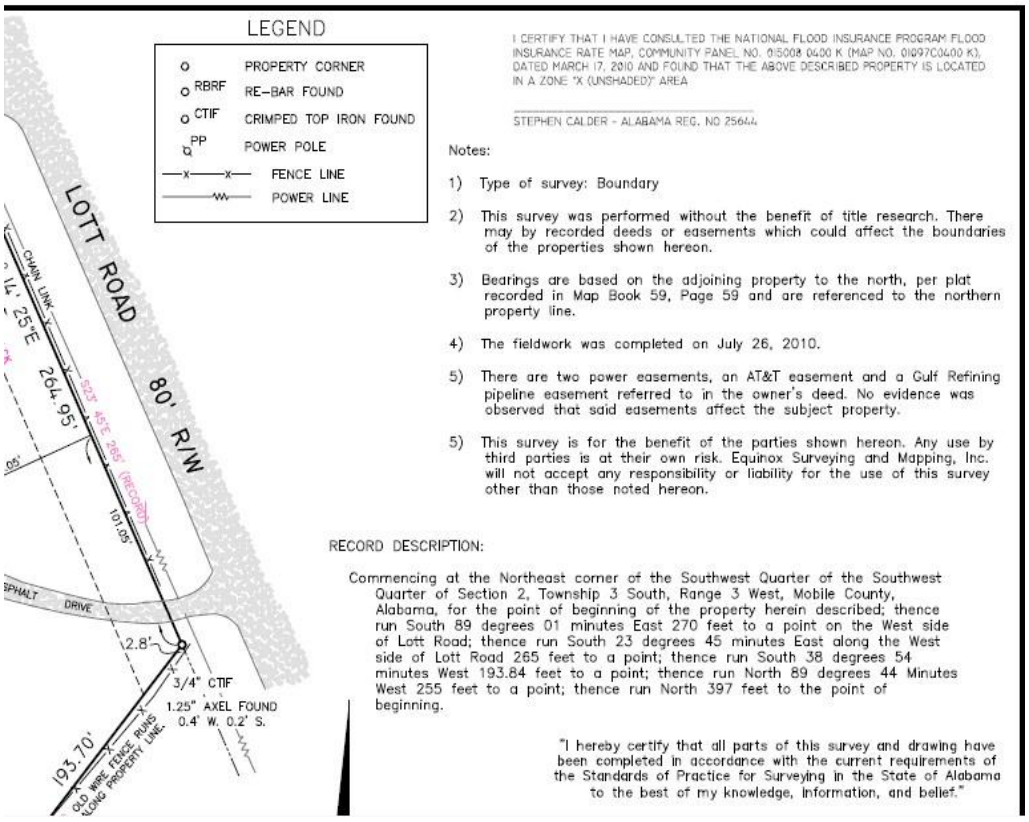




21 Property Boundary Survey Example



22 Property Boundary Survey Example



23 Property Boundary Survey Example

DAY 37

Property Boundary surveying continued. Legal mandates to surveyors.

CAD Lab 15 Drawing a property boundary survey map.

First survey project is due.

DAY 38

Property Boundary surveying continued. Practical application of legal principles to the work of land surveyors.

Field Ex. 16 Review of field work procedures. Maintenance and calibration of survey equipment.

DAY 39

Property Boundary surveying continued. Practical application of legal principles to the work of land surveyors.

CAD Lab 16 Advanced instruction in drawing a property boundary survey map.

DAY 40

Weekly review. Recap of classroom, CAD lab, and field instructions.

Quiz 3

WEEK NINE PROPERTY BOUNDARY PRINCIPLES

DAY 41

Property Boundary surveying continued. Practical application of legal principles to the work of land surveyors. Junior and senior land title rights.

CAD Lab 15 assignment due.

Field Ex. 17 Field work on second survey project begins.

DAY 42

Property Boundary surveying continued. Practical application of legal principles to the work of land surveyors. Junior and senior land title rights.

CAD Lab 17 Office work on the second survey project begins.

DAY 43

Property Boundary surveying continued. Practical application of legal principles to the work of land surveyors. Apportionment.

Field Ex. 18 Work on second survey project continues.

DAY 44

Property Boundary surveying continued. Practical application of legal principles to the work of land surveyors. Preservation of the land title chain.

CAD Lab 18 Work on the second survey project continues.

DAY 45

Weekly review. Recap of classroom, CAD lab, and field instructions.

WEEK TEN CAD PROFICIENCY AND REVIEW OF ERROR PROPAGATION

DAY 46

Advanced CAD concepts. Blocks, layer tools, command shortcuts, text annotation.

CAD Lab 17 assignment due. Field Ex. 19 Work on second survey project.

Advanced CAD Work

- Keyboard shortcuts.
- Advanced layering operations.
- Creating drawing blocks.
- Polyline creation and manipulation.
- Raster image overlays.
- Importing and exporting exogenous file types.

DAY 47

Advanced CAD concepts continued. Creating custom commands. Creating personal work templates.

CAD Lab 19 Advanced CAD concepts. Blocks, layer tools, text annotation,

DAY 48

Advanced CAD concepts completed. Error propagation. Error propagation theory for distance and angular refinement.

Field Ex. 20 Completion of work on second survey project.

DAY 49

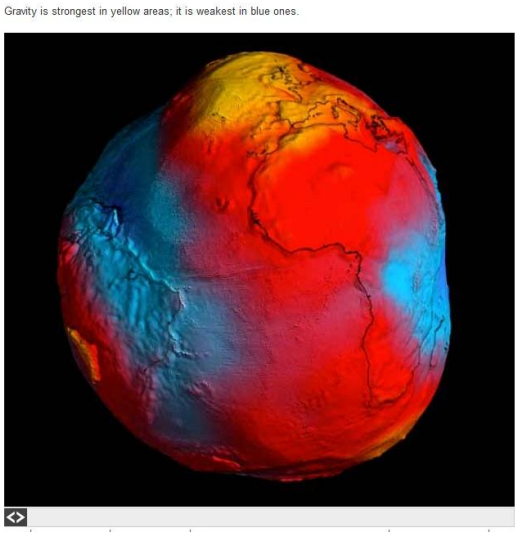
Error propagation continued. Real world example of the effects of error attenuation.

CAD Lab 20 Drawing the second survey project.

DAY 50

Weekly review. Recap of classroom, CAD lab, and field instructions. **Quiz 4**

WEEK ELEVEN GPS AND GIS



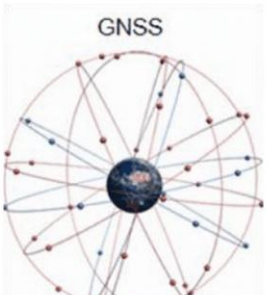
24 Visual Representation of a Geoid Model

DAY 51

GPS. Principles of GPS surveying.

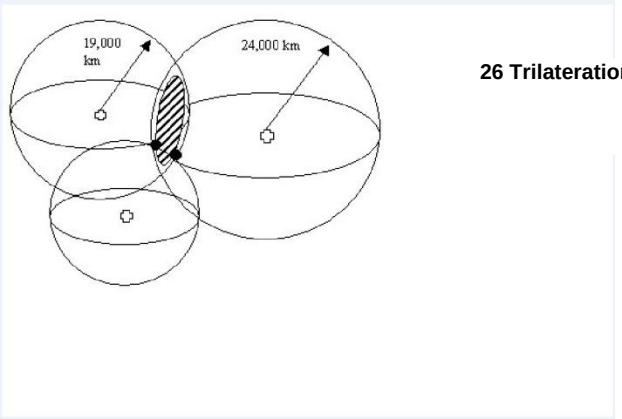
Field Ex. 21 Static GPS baselines and Post Processed Kinematic vectors.

GNSS SURVEYING



25 GPS and GLONASS Constellation

- Principles of satellite telemetry and orbits and satellite trilateration.
- Different satellite constellations.
- History of the American GPS program and current status.
- Frequencies and codes that are broadcast.
- The 3 surfaces: topographic, ellipsoidal, and geoidal.
- Surveying with GNSS methodologies: Static, RTK, Fast Static, and Post-Processed Kinematic.
- Elevation mask angles, PDOP, Multipath, clock Errors, freqency interference.
- Site calibrations.

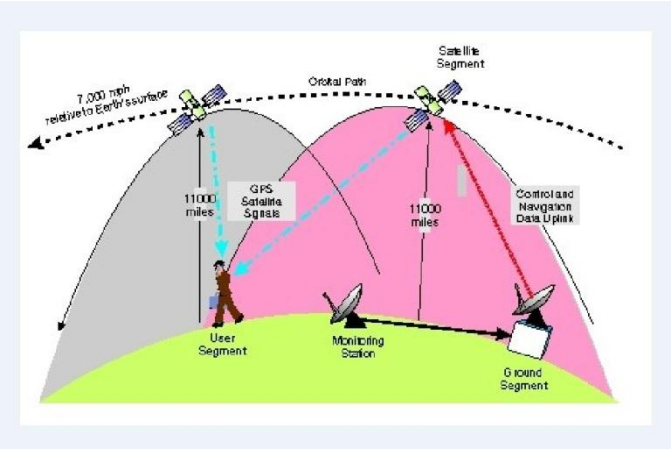


26 Trilateration from Satellite Vehicles

DAY 52

GPS continued. Practical application of GPS control surveying.

CAD Lab 21 Review of layering and shortcut commands.



27 Diagram of GNSS Segments

DAY 53

GPS continued. Advanced concepts of GPS surveying.

GIS. Instruction for working within GIS frameworks. Examples of survey work input to GIS's.

Field Ex. 22 GPS control network.

28 Diagram of the Signal Wavelength

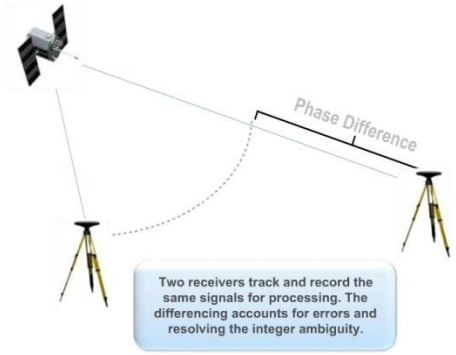
DAY 54

GIS. Arc Info demonstration.

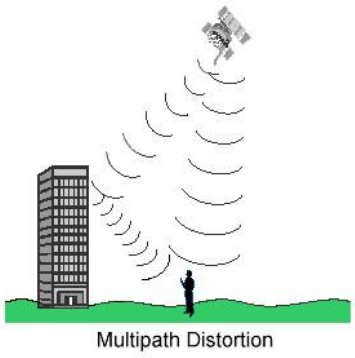
CAD Lab 22 Finalizing second survey project drawing.

DAY 55

Weekly review. Recap of classroom, CAD lab, and field instructions. Preparation for the final week.



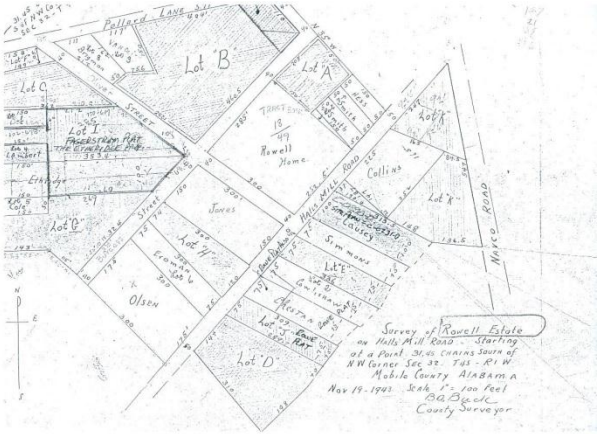
29 **Diagram of Phase Differencing**



30 **Diagram of Signal Multipath**

31 Property Record from Tax Office

32 Property Record from GIS



33 Original Subdivision Property Record

WEEK TWELVE PROJECT MANAGEMENT, PROFESSIONAL ETHICS

DAY 56

Project management. Discussion of management principles. Examples of good and bad management. Work organization forms.

Field Ex. 23 Finalizing second survey project.

DAY 57

Project management continued. Marketing services. Budget preparation. The surveyor and client relationship.

CAD Lab 23 Drawing the second survey project.

DAY 58

Professional ethics. Explanation of ethics and the necessity for ethics to be professional. The surveyor and client relationship.

Field Ex. 24 Finalizing second survey project.

Attributes of a Profession

- Unique and superior education in a specific field of knowledge.
- Service to the public.
- A code of ethics.
- The desire to gain high eminence with financial return of secondary importance.
- Providing services to those unable to pay.
- Intellectual forces brought to bear in rendering of services.

DAY 59

Comprehensive final examination. CAD Lab 24 Presentation of final survey drawing.

Second survey project is due.

DAY 60

Last Day. Presentation of certificates.

ANNEX 1 TEST FOR PROSPECTIVE LAND SURVEYING TECHNICIAN COURSE STUDENTS

Name _____

1. Calculate the following:

a) 287 **b)** 45,319 **c)** 5,266

*25 *57 *132

-------- ---------- ---------

2. Calculate the following:

a) 10,517 **b)** 1,122 **c)** 2,196

÷ 13 ÷ 22 ÷ 9

-------- -------- -------

3. Express as a percent:

a) 0.5 _____ **b)** 2/10 _____ **c)** 75/50 _____

4. A surveyor undertook to determine his walking pace length. He counted 173, 172, 171, 173, 171, and 172 paces in six trials of walking along a 500 ft. course on level ground.

What is the surveyor's average pace length?

_____

5. From the question above, the surveyor then needed an approximate measurement of a property line. He paced it four times resulting in the following number of paces: 211, 212, 210, and 212. What is the best estimate of the length of the property line?

_____

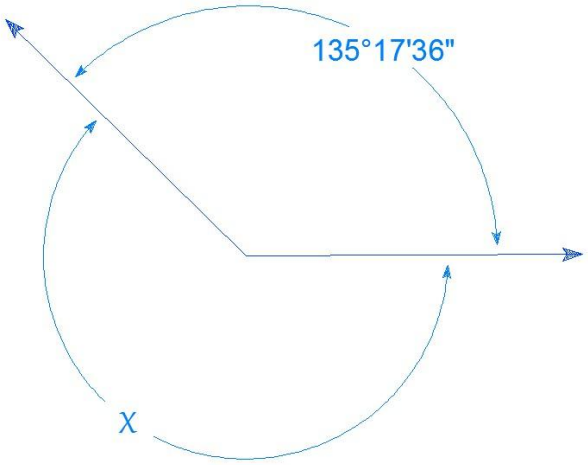
6. List at least four polygons.

_____, _____, _____, _____, _____.

7. True or falser: the sum of interior angles for any triangle = 180°? _____

8. How many degrees are there in any circle? _____

9. What is the value of the conjugate angle *x* in the diagram below?



_____

10.

As the above north arrow indicates the magnetic deviation for this area is West 7°18'20" from true north. You are trying to follow a course on the ground with a record north azimuth of N14°30'30". What compass azimuth should you follow to re-trace the original direction on the ground?

_____

11. Extend this number series: -2, 0, 2, 4, ? _____

12. A ladder leans against a wall. The top of the ladder touches the wall at a point 8' off the ground. The bottom of the ladder touches the ground 6' away from the wall. What is the length of the ladder? Hint: consider the Pythagorean Theorem.

_____

13. Explain these signs:

a) + _____
b) - _____
c) x _____
d) / or ÷ _____
e) = _____
f) > _____
g) < _____
h) 5° _____

14. Round out the following number to 1, 3, 5 and 7 places after the decimal : 34.271568903

a) 1st _____
b) 3rd _____
c) 5th _____
d) 7th _____

15. Write each decimal as a percentage:

a) 0.7 _____ **b)** 0.085 _____ **c)** 0.61 _____

16. You drive a car and you always watch and keep track of your odometer readings (the mileage). After owning the car for two years you make the following modifications: a) you change the oil and the oil filter, b) you change all four tires with new ones of a different size than the originals, c) you start using a different, more efficient burning fuel, d) you install a custom intake manifold which significantly adds to the weight of the engine. After the modifications you notice that the odometer readings for trips you have taken many times in the past are now a little shorter. You also notice that the further the distance you travel, the greater the difference between present and past odometer readings. Which of the modifications made is the most likely cause for the differences?

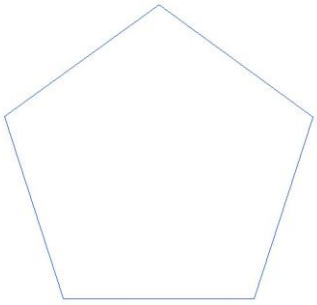
_____

17. Given that:

the Sum of interior angles in a polygon = (n-2)*180

(where n = # of sides of a polygon),

indicate the sum of interior angles for the following figure:



a) _____360°___

b) _____180°___

c) _____540°___

d) _____450°___

18. Calculate the following:

a) 3 + 95 + 4,321 = ? _____
b) 27 + 348 + 5 + 57 = ? _____
c) 0.47 + 6.58 + 3.19 + 39.6 = ? _____

19. Calculate the following:

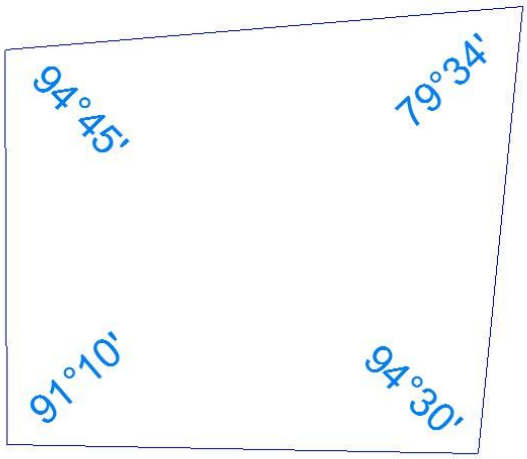
a) 1572 - 352 = ? _____
b) 4.864 – 0.5274 = ? _____
c) 36 + 1864 – 625 + 9 = ? _____

20. Calculate the following:

a) 8523 / 48 = ? _____
b) 126 / 0.06 = ? _____
c) 2856 / 40 = ? _____

21. Either by definition or example, explain the terms area and volume.

22. Using the formula from question #17 above, what is the angular mis-closure of the following polygon?



a) ___0°30'30"___

b) _____0°1'___

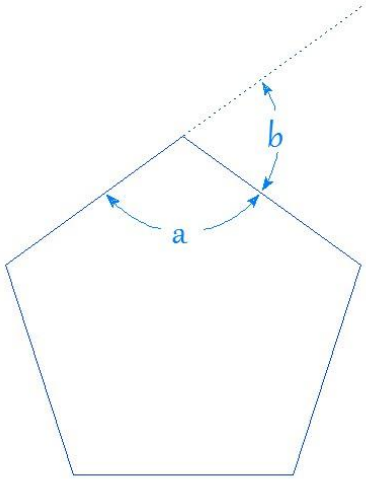
c) _____1°30'___

d) ____0°0'0"___

23. Using the formula from question #17 above, how many sides would a polygon have if the sum of its interior angles were equal to 720°?

_____

24. Assuming the figure shown is a regular polygon with all sides and angles equal what is the value for *b*?



_____

25. Briefly describe your interest in surveying?

26. Write a brief introduction of yourself (approximately 10 sentences or 100 words).

ANSWERS TO TEST QUESTIONS

1. Calculate the following: **3%**

b) 287 *25 --- **7,175**

b) 45,319 *57 --- **2,583,183**

c) 5,266 *132 --- **695,112**

2. Calculate the following: **3%**

a) 10,517 ÷ 13 --- **809**

b) 1,122 ÷ 22 --- **51**

c) 2,196 ÷ 9 --- **244**

3. Express as a percent: **3%**

b) 0.5 **__50%__**

b) 2/10 **__20%__**

c) 75/50 **__150%__**

4. A surveyor undertook to determine his walking pace length. He counted 173, 172, 171, 173, 171, and 172 paces in six trials of walking along a 500 ft. course on level ground.

What is the surveyor's average pace length? **5%**

_____2.91'_____ (or simply 2.9')

5. From the question above, the surveyor then needed an approximate measurement of a property line. He paced it four times resulting in the following number of paces: 211, 212, 210, and 212. What is the best estimate of the length of the property line? **4%**

_____615'_____ Note: the precision of 614.74' is meaningless in a pacing exercise.

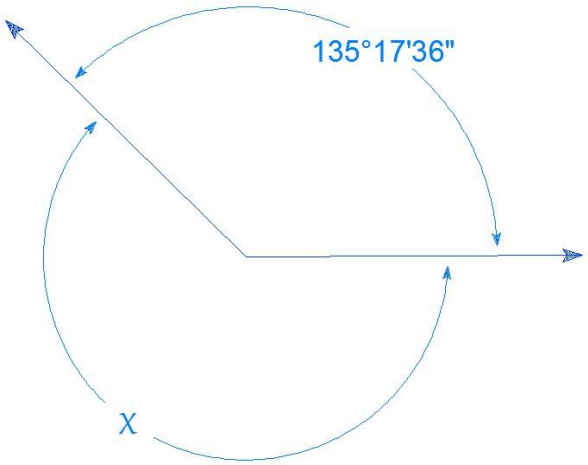
6. List at least four polygons. **2%**

Triangle, _Square__, _Rectangle_, _Pentagon_, _Hexagon_.

7. True or False: the sum of interior angles for any triangle = 180°? **4%** **____True____**

8. How many degrees are there in any circle? **4%** ____**360°**____

9. What is the value of the conjugate angle *x* in the diagram below? **4% (Grade the degrees only.)**



_____**224°42'24"**_____

10.

As the above north arrow indicates the magnetic deviation for this area is West 7°18'20" from True North. You are trying to follow a course on the ground with a record north azimuth of N14°30'30". What compass azimuth should you follow to re-trace the original direction on the ground? **3% (Grade the degrees only.)**

_____**21°48'50"**_____

11. Extend this number series: -2, 0, 2, 4, ? **2%** ___**6**__

12. A ladder leans against a wall. The top of the ladder touches the wall at a point 8' off the ground. The bottom of the ladder touches the ground 6' away from the wall. What is the length of the ladder? Hint: consider the Pythagorean Theorem. **5%**

_____**10'**_____

13. Give the name for the following signs: **8%**

a) + __plus, add _____
b) - __minus, subtract_
c) x __times, multiply_
d) / or ÷ ___divide_____
e) = __equals_____
f) > _greater than_
g) < __less than____
h) 5° ___degrees____

14. Round out the following number to 1, 3, 5 and 7 places after the decimal: **4%** 34.271568903

a) 1st __**34.3**__
b) 3rd __**34.272**__

c) 5th _**34.27157**__

d) 7th _**34.2715689**_

15. Write each decimal as a percentage: **6%**

b) 0.7 **70%** **b)** 0.085 **8.5%** **c)** 0.61 **61%**

16. You drive a car and you always watch and keep track of your odometer readings (the mileage). After owning the car for two years you make the following modifications: a) you change the oil and the oil filter, b) you change all four tires with new ones of a different size than the originals, c) you start using a different, more efficient burning fuel, d) you install a custom intake manifold which significantly adds to the weight of the engine. After the modifications you notice that the odometer readings for trips you have taken many times in the past are now a little shorter. You also notice that the further the distance you travel, the greater the difference between present and past odometer readings.

Which of the modifications made is the most likely cause for the differences? **5%**

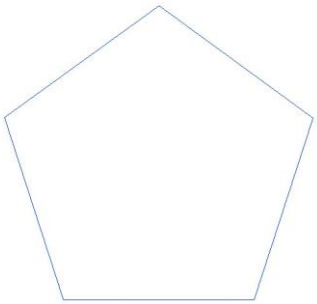
_____ **Only the changed tires could account for the differences.**___

17. Given that:

the Sum of interior angles in a polygon = (n-2)*180

(where n = # of sides of a polygon),

indicate the sum of interior angles for the following figure: **4%**



a) _____360°___

b) _____180°___

c) _____**540°**___

d) _____450°___

18. Calculate the following: **3%**

a) 3 + 95 + 4,321 = ? **__4,419__**
b) 27 + 348 + 5 + 57 = ? **___437___**
c) 0.47 + 6.58 + 3.19 + 39.6 = ? **_49.84___**

19. Calculate the following: **3%**

a) 1572 - 352 = ? **_1,220_____**
b) 4.864 – 0.5274 = ? **___4.3366___**
c) 36 + 1864 – 625 + 9 = ? **____1,284_____**

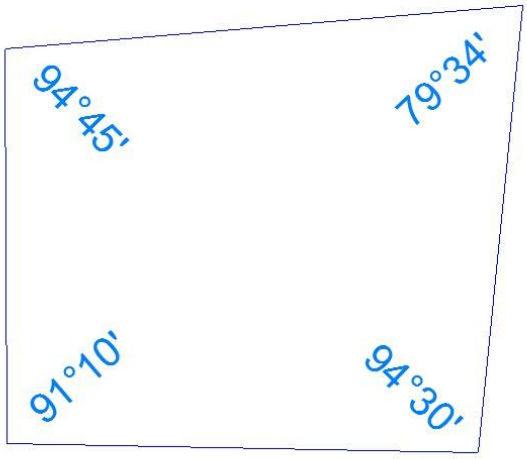
20. Calculate the following: **3%**

a) 8523 / 48 = ? **__177.563_**
b) 126 / 0.06 = ? **__2,100___**
c) 2856 / 40 = ? **___71.4___**

21. Either by definition or example, explain the terms area and volume. **2%**

Area is a two dimensional quantity of enclosed surface or shape.
Volume is a three dimensional quantity of enclosed space.

22. Using the formula from question #17 above, what is the angular mis-closure of the following polygon? **3%**

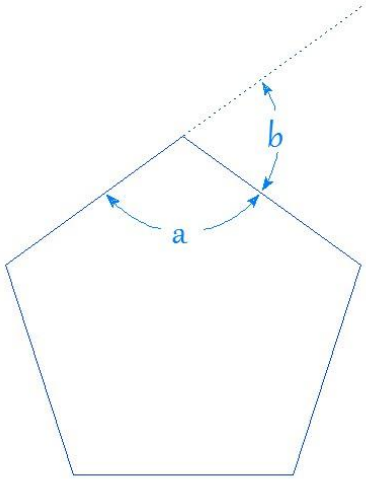


a) ___0°30'30"___
b) _____**0°1'**___
c) _____1°30'___
d) ____0°0'0"___

23. Using the formula from the question #17 above, how many sides would a polygon have if the sum of its interior angles were equal to 720°? **3%**

____**6**____

24. Assuming the figure shown is a regular polygon with all sides and angles equal what is the value for *b*? **4%**



_____72°_____

25. Briefly describe your interest in surveying? **5%**

26. Write a brief introduction of yourself (approximately 10 sentences or 100 words). **5%**

U.S. Agency for International Development/Liberia
P.O. Box 10-1445
1000 Monrovia 10
Liberia
Tel: 231-77-054-825 or 231-77-054-826
Fax: 231-226-152
http://liberia.usaid.gov