PART I:
SOLUTIONS TO PROBLEMS

1 INTRODUCTION

NOTE: Answers for some of these problems, and some in later chapters, can be obtained by consulting the bibliographies, later chapters, websites, or professional surveyors.

1.1 List 10 uses for surveying in areas other than boundary surveying.

Answers may vary many are included in Section 1.6, which lists control, topographic hydrographic, alignment, construction, as-built, mine, solar, optical tooling, ground, aerial, and satellite surveys. This list is not complete and could also include other types of surveys such as hydrographic surveys, for example.

1.2 Explain the difference between geodetic and plane surveys.

From Section 1.4:
In geodetic surveys the curved surface of the earth is considered by performing the computations on an ellipsoid (curve surface approximating the size and shape of the earth). In plane surveys, except for leveling, the reference base for fieldwork and computations is assumed to be a flat horizontal surface. The direction of a plumb line (and thus gravity) is considered parallel throughout the survey region, and all measured angles are presumed to be plane angles.

1.3 Describe some surveying applications in:

(a) Archeology
There are many different uses of surveying in archeology. Some include using sonar to identify possible underground or underwater archeology sites, LiDAR to help identify possible ancient human settlements in unexplored forest and jungles, and traditional surveying and laser scanning to help locate artifacts in site excavations.

(b) Gas exploration
There are several stages of surveying in gas exploration, which include but are not limited to determining anomalies in the gravity field, which identify possible gas deposits, boundary surveys identifying properties that have mineral rights to the gas deposits, alignment surveys for placement of pipelines to transport extracted gas.

(c) Agriculture
In agriculture, surveying is used to determine the acreage of fields, to locate lines of constant elevation for strip farming, to track harvesting machinery to enable the size of the harvest, and to track the position of the planting equipment to allow for precise applications of seeds and fertilizers. The field is known as high-precision agriculture.

1.4 List some application of surveying in geology, forestry, and archeology.

Applications in each are multiple. For some in geology and archeology see the answer to Problem 1.3 (a) and (b). Some uses of surveying in forestry identifying forest boundaries, locating spread of diseases and insects through remote sensing, using GIS to help inventory and keep records on resources in forested regions.

1.5 Why is it important to make accurate surveys of underground utilities?

To provide an accurate record of the locations of these utilities so they can be found if repairs or servicing is needed, and to prevent their accidental destruction during excavation for other projects.

1.6 Discuss the uses for topographic surveys.

Topographic surveys are used whenever elevation data is required in the end product. Some examples include (1) creating maps for highway design; (2) creating maps for construction surveys; (3) creating maps for flood plain delineation; (4) creating maps for site location of buildings; and so on.

1.7 What are hydrographic surveys, and why are they important?

From Section 1.6, hydrographic surveys define shorelines and depths of lakes, streams, oceans, reservoirs, and other bodies of water. Sea surveying is associated with port and offshore industries and the marine environment, including measurements and marine investigations made by ship borne personnel.

1.8 Print a view of your location using Google Earth.®

Answers will vary but should be an image in your region.

1.9 Briefly explain the procedure used by Eratosthenes in determining the Earth’s circumference.

From Section 1.3, paragraph 8 of text: His procedure, which occurred about 200 B.C., is illustrated in Figure 1.3. Eratosthenes had concluded that the Egyptian cities of Alexandria and Syene were located approximately on the same meridian, and he had also observed that at noon on the summer solstice, the sun was directly overhead at Syene. (This was apparent because at that time of that day, the image of the sun could be seen reflecting from the bottom of a deep vertical well there.) He reasoned that at that moment, the sun, Syene, and Alexandria were in a common meridian plane, and if he could measure the arc length between the two cities, and the angle it subtended at the earth's center, he could compute the earth's circumference. He determined the angle by measuring the length of the shadow cast at Alexandria from a tall vertical staff of known length. The arc length was found from multiplying the number of caravan days between Syene and Alexandria by the average daily distance traveled. From these measurements

Eratosthenes calculated the earth's circumference to be about 25,000 mi. Subsequent precise geodetic measurements using better instruments, but techniques similar geometrically to Eratosthenes', have shown his value, though slightly too large, to be amazingly close to the currently accepted one.

1.10 Describe the steps a land surveyor would need to do when performing a boundary survey.

Briefly, the steps should include (1) preliminary walking of property with owner; (2) courthouse research to locate deed of property and adjoiners to determine ownership, possible easements, right-of-ways, conflicts of interest, and so on; (3) location survey of property noting any encroachments; conflicting elements; and so on; (4) resolution of conflicting elements between deed and survey; (5) delivery of surveying report to owner.

1.11 What is the name of the state-level professional surveying organization in your state or region?

Answer will vary by location.

1.12 What organizations in your state furnish maps and reference data to surveyors and engineers?

Responses will vary but some common organizations are the (1) county surveyor, (2) register of deeds, (3) county engineer or county highway department (4) Department of Transportation, (5) Department of Natural Resources of its equivalent, and so on.

1.13 List the legal requirements for registration as a land surveyor in your state.

Responses will vary. Contact with your licensing board can be found on the NCEES website at http://www.ncees.org/licensure/licensing_boards/.

1.14 Briefly describe an Earth-Centered, Earth-Fixed coordinate system.

From Section 1.4 and 13.4.3, a ECEF coordinate system is an Earth-based three-dimensional coordinate system with its origin a the mass-center of the Earth, it Z axis aligned with the semi-minor (spin) axis of the Earth defined at some epoch, it X axis in the plane of the equator passing through mean Greenwich meridian, and it Y axis in the plane of the equator and creating a right-handed coordinate system. At this stage of their introduction to surveying it should be sufficient for students to simply know that it is an Earth-based three-dimensional coordinate system.

1.15 List the professional societies representing the geospatial industry in the

(a) United States.

There are several including AAGS, ASCE, ASPRS, GLIS, NSPS, and SaGES.

(b) Canada.

Canadian Institute of Geomatics (CIG)

(c) International.

International Federation of Surveyors (FIG)

1.15 Explain how aerial photographs and satellite images can be valuable in surveying.

Photogrammetry presently has many applications in surveying. It is used, for example, in land surveying to compute coordinates of section corners, boundary corners, or point of evidence that help locate these corners. Large–scale maps are made by photogrammetric procedures for many uses, one being subdivision design. Photogrammetry is used to map shorelines, in hydrographic surveying, to determine precise ground coordinates of points in control surveying, and to develop maps and cross sections for route and engineering surveys. Photogrammetry is playing an important role in developing the necessary data for modern Land and Geographic Information Systems.

1.16 Search the Internet and define a Very Long Baseline Interferometry (VLBI) station. Discuss why these stations are important to the geospatial industry.

VLBI stands for Very Long Baseline Interferometry. Responses will vary. These stations provide extremely accurate locations on the surface of the Earth. The stations are used to develop world-wide reference frameworks such as ITRF08 and thus provide a worldwide coordinate system that links continents. They also may provide tracking information for satellites.

1.17 Describe how a GIS can be used in flood emergency planning.

Responses will vary but may mention the capabilities of a GIS to overlay soil type and their permeability with slopes, soil saturation, and watershed regions. A GIS can also be used to provide a list of business and residences that will be affected by possible flooding for evacuation purposes. It can provide "best" routes out of a flooded region.

1.19 Visit one of the surveying websites listed in Table 1.1, and write a brief summary of its contents. Briefly explain the value of the available information to surveyors.

Responses will vary with time, but below are brief responses to the question

- NGS – control data sheets, CORS data, surveying software
- USGS – maps, software
- BLM – cadastral maps, software, ephemerides
- U.S. Coast Guard Navigation Center - GPS information
- U.S. Naval Observatory –Notice Advisory for NAVSTAR Users (NANU) and other GPS related links
- National Society of Professional Surveyors – professional organization for boundary and construction
- American Association for Geodetic Surveying – professional organization for control surveying
- Geographic and Land Information Society – professional organization for developers and users of geographic and land information systems

- American Society for Photogrammetry and Remote Sensing – professional organization for photogrammetry and remote sensing
- The Pearson Prentice Hall publishers access to software and support materials that accompany this book.
- SaGES – An organization to advance surveying/geomatics education

1.20 Read one of the articles cited in the bibliography for this chapter, or another of your choosing, that describes an application where satellite surveying methods were used. Write a brief summary of the article.

Answer will vary.

1.21 Same as Problem 1.20, except the article should be on safety as related to surveying.

Answers will vary but should be related to safety issues in surveying.

1.20 Read one of the articles cited in the bibliography for this chapter, or another of your choosing, that describes an application where satellite surveying methods were used. Write a brief summary of the article.

Answers will vary. Students should be told to look in trade journals for articles.

1.21 Same as Problem 1.20, except the article should be on safety as related to surveying.

Answers will vary. Students should be told to look in trade journals for articles.

2 UNITS, SIGNIFICANT FIGURES, AND FIELD NOTES

2.1 List the five types of measurements that form the basis of traditional plane surveying.

From Section 2.1, they are (1) horizontal angles, (2) horizontal distances, (3) vertical (altitude or zenith) angles, (4) vertical distances, and (5) slope (or slant) distances.

2.2 Give the basic units that are used in surveying for length, area, volume, and angles in

(a) The English system of units.

From Section 2.2:

length (U.S. survey ft or in some states international foot), area (sq. ft. or acres), volume (cu. ft. or cu. yd.), angle (sexagesimal)

(b) The SI system of units.

From Section 2.3:

length (m), area (sq. m. or hectare), volume (cu. m.), angle (sexagesimal, grad, or radian)

2.3 The easting coordinate for a point is 725,316.911 m. What is the coordinate using the

(a) Survey foot definition?

(b) International foot definition?

(c) Why was the survey foot definition maintained in the United States?

(a) **<u>2,379,643.90 sft</u>**; $725{,}316.911\left(\frac{39.37}{12}\right) = 2{,}379{,}643.899$ sft

(b) **<u>2,379,648,66 ft</u>**; $725{,}316.911/0.3048 = 2{,}379{,}648.658$ ft

(c) From Section 2.2: "Because of the vast number of surveys performed prior to 1959, it would have been extremely difficult and confusing to change all related documents and maps that already existed. Thus the old standard, now called the *U.S. survey foot*, is still used."

2.4 Convert the following distances given in meters to U.S. survey feet:

***(a)** 4129.574 m **<u>13,548.44 sft</u>**

(b) 588.234 m **<u>1929.90 sft</u>**

(c) 102,302.103 m **<u>335,636.15 sft</u>**

2.5 Convert the following distances given in survey feet to meters:

***(a)** 537.52 sft **<u>163.836 m</u>**

(b) 2,405,687.82 sft **<u>733,255.114 m</u>**

(c) 5783.12 sft **<u>1762.699 m or 1762.70 m</u>**

2.6 Compute the lengths in survey feet corresponding to the following distances measured with a Gunter's chain:

***(a)** 10 ch 13 lk **<u>668.6 sft</u>**

(b) 56 ch 83 lk **<u>3750.8 sft</u>**

(c) 124 ch 35 lk **<u>8207.1 sft</u>**

2.7 Express 5,377,700 sft^2 in:

***(a)** acres **<u>123.46 ac</u>**

(b) hectares **<u>49.961 ha</u>**

(c) square Gunter's chains **<u>1234.6 sq. ch.</u>**

2.8 Convert 23.4587 ha to:

(a) square survey feet **<u>2,525,070 sft^2</u>**

(b) acres **<u>57.9676 ac</u>**

(b) square Gunter's chains **<u>579.676 sq. ch</u>**

2.9 What are the lengths in feet and decimals for the following distances shown on a building blueprint:

(a) 12 ft 6-1/4 in. **<u>12.5 ft</u>** 601/4/12

(b) 10 ft 6-1/2 in. **<u>10.5 ft</u>** 253/2/12

2.10 What is the area in acres of a rectangular parcel of land measured with a Gunter's chain if the recorded sides are as follows:

***(a)** 9.17 ch and 10.64 ch **<u>9.76 ac</u>**

(b) 16 ch 78 lk and 52 ch 49 lk **<u>88.08 ac</u>**

2.11 Compute the area in acres of triangular lots shown on a plat having the following recorded right-angle sides:

(a) 335.36 ft and 804.02 ft **<u>3.0945 ac</u>**

(b) 93.064 m and 30.346 m **<u>0.69785 ac</u>**

2.12 A distance is expressed as 9756.12 sft. What is the length in

***(a)** international feet? **<u>9756.14 ft</u>**

(b) meters? **<u>2973.67 m</u>**

2.13 What are the radian and degree-minute-second equivalents for the following angles given in grads:

(a)* 136.000 grads **<u>122°24′00"; 2.13628 rad</u>**

(b) 115.089 grads **<u>103°34′50″; 1.80781 rad</u>**

(c) 363.809 grads **<u>327°25′40″; 5.71469 rad</u>**

2.14 Give answers to the following problems in the correct number of significant figures:

*(**a**) sum of 23.15, 0.984, 124, and 12.5 **<u>161</u>**

(b) sum of 2.115, 23.04, 13.8, and 199.66 **<u>238.6</u>**

(c) product of 127.08 and 13.1 **<u>1660</u>**

(d) quotient of 4466.83 divided by 35.61 **<u>125.4</u>**

2.15 Express the value or answer in powers of 10 to the correct number of significant figures:

(a) 4586.49 **<u>4.58679×10^3</u>**

(b) 2450 **<u>2.45×10^3</u>**

(c) square of 199.99 **<u>3.9996×10^4</u>**

(d) sum of (32.087 + 1.56 + 206.44) divided by 2.3 **<u>1.95×10^1</u>**

2.16 Convert the angles of a triangle to radians and show a computational check:

*(**a**) 39°41′54, 91°30'16", 48°47′50" **<u>0.692867, 1.59705,</u>** and **<u>0.851672</u>**

0.6928666 + 1.597054 + 0.8516721 = <u>3.14159 check</u>

(b) 96°23'18, 44°56′53", 38°39′49" **<u>1.68229, 0.784492</u>**, and **<u>0.674807</u>**

1.682294 + 0.784492 + 0.674807 = <u>3.14159 check</u>

2.17 Why should a ball point pen not be used in field notekeeping?

From Section 2.7: "Books so prepared (with 3h or higher pencil) will withstand damp weather in the field (or even a soaking) and still be legible, whereas graphite from a soft pencil, or ink from a pen or ballpoint, leaves an undecipherable smudge under such circumstances."

2.18 Explain why one number should not be superimposed over another or the lines of sketches.

From Section 2.7: This can be explained with the need for integrity since it would raise the issue of what are you hiding, legibility since the numbers are often hard to interpret when so written, or by clarity since the notes are being crowded.

2.19 Explain why data should always be entered directly into the field book at the time measurements are made, rather than on scrap paper for neat transfer to the field book later.

From Section 2.7: Data should always be entered into the field book directly at the time of the measurements to avoid loss of data.

2.20 Why should the field notes show the precision of the measurements?

Field notes should show the precision of the measurements made to indicate the accuracy of the measurements.

2.21 Explain the reason for item 7 in Section 2.11 when recording field notes.

In general a sketch will show more than a table of numbers. As the saying goes, "A picture is worth a thousand words."

2.22 Explain the reason for item 13 in Section 2.11 when recording field notes.

A standard set of symbols and signs improve the clarity of drawings.

2.23 Explain the reason for item 18 in Section 2.11 when recording field notes.

A zero should be placed before a decimal point for the sake of clarity.

2.24 When should sketches be made instead of just recording data?

Sketches should be made instead of recording data anytime observations need to be clarified so that the personnel interpreting the notes can have a clear understanding of the field conditions. This also serves as a reminder of the work performed and any unusual conditions in later references to the project.

2.25 Justify the requirement to list in a field book the makes and serial numbers of all instruments used on a survey.

Listing the makes and serial numbers of the instruments used in the survey may help isolate instrumental errors later when reviewing the project.

2.26 Discuss the advantages of survey controllers that can communicate with several different types of instruments.

The ability of survey controllers to communicate with several different types of instruments allows the surveyor to match the specific conditions of the project with the instrument that this is ideally suited for the job. Thus total station, digital levels, and GNSS receivers can all be used in a single project.

2.27 Discuss why data should always be backed up at regular intervals.

From Section 2.13, paragraph 1: "At regular intervals, usually at lunchtime and at the end of a day's work, or when a survey has been completed, the information stored in files within a data collector is transferred to another device. This is a safety precaution to avoid accidentally losing substantial amounts of data."

2.28 Search the Internet and find at least two sites related to

(a) Manufacturers of survey controllers.

(b) Manufacturers of total stations.

(c) Manufacturers of global navigation satellite system (GNSS) receivers.

<u>Answers should vary with students.</u>

2.29 Why do many survey controllers contain digital cameras?

From Section 2.15: “Many modern survey controllers also contain digital cameras that allow field personnel to capture a digital image of the survey.”

2.30 What are the dangers involved in using a survey controller?

From Section 2.15: “Although survey controllers have many advantages, they also present some dangers and problems. There is the slight chance, for example, the files could be accidentally erased through carelessness or lost because of malfunction or damage to the unit.”

2.31 Describe what is meant by the phrase “field-to-finish.”

From Section 2.15, "The field codes can instruct the drafting software to draw a map of the data complete with lines, curves and mapping symbols. The process of collecting field data with field codes that can be interpreted later by software is known as a *field-to-finish* survey. This greatly reduces the time needed to complete a project."

2.32 Why are sketches in field books not usually drawn to scale?

This is true since this would require an overwhelming amount of time. The sketches are simply to provide readers of the notes an approximate visual reference to the measurements.