17 MAPPING SURVEYS

Asterisks $^{(*)}$ indicate problems that have answers given in Appendix G.

17.1 Describe what features are located on a topographic map.

From Section 17.1, Paragraph 2: "Two different types of maps, *planimetric* and *topographic*, are prepared as a result of mapping surveys. The former depicts natural and cultural features in the plan (X-Y) views only. Objects shown are called planimetric features. Topographic maps also include planimetric features, but in addition they show the configuration of the Earth's surface."

17.2 Name five mapping details classified as "cultural" features not mentioned in Section 17.1.

Airports, cities, towns, etc.

17.3 What factors must be considered when selecting the contour interval to be used for a given topographic map.

From Section 17.5, paragraph 4: "The contour interval selected depends on a map's purpose and scale, and upon the diversity of relief in the area."

17.4 List the different methods that can be used for a ground survey to perform a mapping survey.

From Section 17.9, paragraph 2: "Location of planimetric features and contours can be accomplished by one of the following field procedures: (1) radiation by total station instrument, (2) coordinate squares or "grid" method, (3) offsets from a reference line, (4) use of portable GNSS units, (5) use of laser scanners, or (6) a combination of these methods. An explanation of each system and a discussion on their uses, advantages, and disadvantages follow."

17.5 Why are spot elevations placed on a map?

From Section 17.5, paragraph 5: " *Spot elevations* are used on maps to mark unique or critical points such as peaks, potholes, valleys, streams, and highway crossings. They may also be used in lieu of contours for defining elevations on relatively flat terrain that extends over a large area."

17.6* On a map sheet having a scale of 1 in. = 360 ft, what is the smallest distance (in feet) that can be plotted with an engineer's scale? (Minimum scale graduations are 1/60th in.)

$$\underline{\mathbf{6\ ft}} = \frac{1}{60} 360 \text{ ft}$$

17.7 What equivalent scales are suitable to replace the following ratio scales: 1:600, 1:1200, 1:6000, and 1:9600?

1 in. = 50 ft, 1 in. = 100 ft, 1 in. = 500 ft, 1 in. = 800 ft, respectively.

17.8 A topographic map has a contour interval of 1 ft and a scale of 1:480. If two adjacent contours are 0.5 in. apart, what is the average slope of the ground between the contours?

5%; scale =40 ft/in. H = 40*0.5 = 20 ft; slope = 1/20*100%

17.9* On a map whose scale is 1 in. = 50 ft, how far apart (in inches) would 2-ft contours be on a uniform slope (grade) of 2%?

2 in. x = 2/0.02 = 100 ft, map dist = 100 ft/50 ft/in. = 2 in.

17.10 On a map drawn to a scale of 1:1000 contour lines are 20 mm apart at a certain place. The contour interval is 1 m. What is the ground slope, in percent, between adjacent contours?

5% H = 0.020(1000) = 20 m; Slope = 1/20 = 5%

17.11 Similar to Problem 17.10, except for a 5-m interval, 20-mm spacing, and a map scale of 1:5000.

5%, H = 0.020(5000) = 100 m, Slope = 5/100 = 5%

17.12 What are the ratio scales for the equivalent scales of 1 in. = 10 ft, 1 cm = 10 m, and 1 in. = 40 ft?

1:120, 1:1000, 1:480, respectively.

17.13 Sketch at a scale of 1:120, the general shape of contours that cross a 20-ft wide street have a +4.00% grade, 6-in. parabolic crown, and a 6 in. high curb.

Student sketch

17.14 When should points be located for contours connected by straight lines? When by smooth curves?

Straight line: When slope of ground is uniform as on a highway

Smooth curves: When slope of ground is gradually changing on gently rolling land.

17.15* What conditions in the field need to exist when using kinematic satellite survey?

No overhead obstructions/Canopy restrictions or multipathing conditions

17.16 What is a digital elevation model?

From Section 17.8, paragraph 1: "Data for use in automated contouring systems is collected in arrays of points whose horizontal positions are given by their *X* and *Y* coordinates and whose elevations are given as *Z* coordinates. Such three-dimensional arrays provide a *digital* representation of the continuous variation of relief over an area and are known as *digital elevation models* (DEMs). Alternatively, the term *digital terrain model* (DTM) is sometimes used."

17.17 Discuss why it is important to locate breaks in grade with "breaklines" in the field if contours will be drawn using a computerized automated contouring system.

From Section 17.8, paragraph 6: "Breaklines are linear topographic features that delineate the intersection of two surfaces that have uniform slopes, and thus define changes in grade. *Automated mapping algorithms use these lines to define sides of the triangles that form the TIN model, and thus elevations are interpolated along them.*"

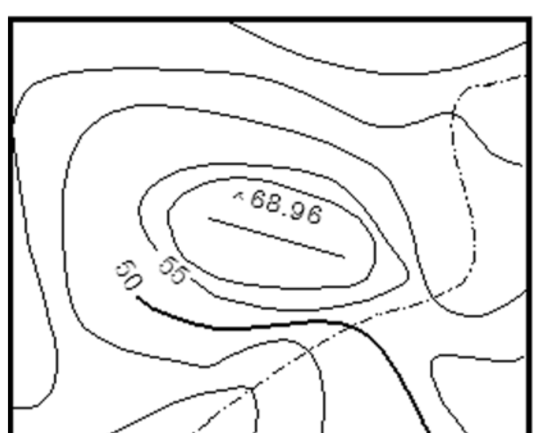
17.18 What considerations should be given to a mapping survey using GNSS satellites?

From Chapter 15, receivers can not locate points close to buildings due to multipathing or under overhead obstructions. Additionally, in topographic surveys, the geodetic heights must be converted to orthometric heights (elevations).

17.19 How could GNSS survey methods be used where the area of interest has some overhead obstructions?

From Section 17.9.4, paragraph 4: "Thus, GNSS surveys are generally not be suitable for direct location of large trees, buildings, or other objects that could obscure the view of the satellites or create multipathing conditions. In these situations, a procedure known as offset location can be used. When locating an object by offsets, two points are established using the GNSS receiver where clear view to the satellites is possible. These two locations need to create a line that points to the object being located; this establishes the azimuth of the line. A distance is then observed from one of the two points using a tape and manually entered into the survey controller. Using the azimuth of the line and the distance, the coordinates of the object are determined in the collector. If the area contains several objects that are not accessible to GNSS receivers, nearby temporary control stations can be established using the stop-and-go method and conventional data collection with total stations used to locate these map details by occupying one point and backsighting the other. Due to overhead obstructions and multipathing conditions, GNSS receivers should not be placed at the corners of buildings. In this instance, successive corners of the building can be located by offsets. Some survey controller software provides an option to tape the remaining sides of the building to create footprint of the building."

17.20 Using the rules of contours, list the contouring mistakes that are shown in the accompanying figure and list the contouring rule it violates.



1. 65-ft contour violates item 10, which states that contours go in pairs along sides of ridges and item 11.
2. 55-ft contour should not be labeled.
3. 50-ft contour is not continuous which violates item 1.

4. 45-ft contour violates item 9 since it points both up and down the stream

17.21 Discuss how a survey controller with a total station instrument can be combined with satellite surveying methods to collect data for a topographic map.

A survey controller can often interface with both a total station and a GNSS receiver. Thus the GNSS receiver can establish the coordinate system and necessary control to support the survey. It can also be used to collect data on features and grade points where overhead obstructions and multipathing are not a problem. The total station can then be interfaced with the same survey controller in the same project file and be used to complete the survey in areas where the GNSS receiver could not be used.

17.22 Assuming *xy* coordinates for the instrument station of (5000, 5000), a backsight azimuth of $14°26'48''$, and height of instrument of 853.76 ft, determine the coordinates and elevations for points 3, 4, and 5 in Table 17.1.

Point	Hor. Angle	Zen. Angle	Distance	Notes
3	16°37'44"	90°25'50"	565.855	DTREE 24-in. Maple
4	70°35'24"	91°15'48"	436.472	MH Sanitary manhole
5	225°14'22"	88°30'36"	265.934	.BDG SE Corner of Building

Point	Azimuth	H-Dist	V-Dist	***x***	***y***	**H**
3	31°4'32"	565.84	-4.25	**5292.1**	**5484.6**	**849.51**
4	85°2'12"	436.36	-9.62	**5726.8**	**5522.4**	**839.88**
5	239°41'10"	265.84	6.91	**5497.3**	**5388.2**	**846.80**

17.23 What disadvantage can occur if a control traverse is performed at the same time as planimetric data is being collected?

From Section 17.4, paragraph 4: "Regardless of the methods used in conducting the control surveys for mapping projects, specified maximum allowable closure errors for both horizontal and vertical control should be determined in advance of the fieldwork, then used to guide it. The locations of the features, which comprise the map (often also called *map details*), are based upon the framework of control points whose positions and elevations are established. Thus, any errors in the surveyed positions or elevations of the control points will result in erroneous locations of the details on the map. Therefore, it is advisable to run, check, and adjust the horizontal and vertical control surveys before beginning to locate map details, rather than carry on both processes simultaneously."

17.24 Discuss how a survey controller with a total station instrument can be combined with GPS methods to collect data for a topographic map.

A survey controller can often interface with both a GNSS receiver and a total station. Thus GNSS receivers can be used to establish a coordinate system for the survey, control points, and perform as much of the survey as physically possible. In areas where signal loss or multipathing are a problem, a total station can be connected to the same controller project and fill in the remaining data in the same project using GNSS established points for occupation and azimuth.

17.25 What does the term "point cloud" describe in laser-scanning?

From Section 17.9.5, paragraph 2: "The resulting grid of scanned, three-dimensional points can be so dense that a visual image of the scene is formed. This so-called "point-cloud" image differs from a photographic image in that every point has a three-dimensional coordinate assigned to it. These coordinates can be used to obtain dimensions between any two observed points in the scene."

17.26 What factors must be considered when planning a laser scanning survey?

From Section 17.10: Part of the planning for a laser scanning survey is to determine the ideal locations to setup the scanner. Establishing a method of creating a consistent set of coordinates from multiple scan through the use of a traverse or the placement of multiple targets on the surface of the object being scanned that will extend the coordinates from the first scan to subsequent scans. Additionally, the resolution of the scan must be set to a sufficient density to satisfy project requirements.

For Problems 17.27 through 17.30, calculate the *X*, *Y* and *Z* coordinates of point *B* for radial readings taken to *B* from occupied station *A*, if the backsight azimuth at *A* is 63°03'18", the elevation of *A* = 1210.06 ft, and *hi* = 5.63 ft. Assume the *XY* coordinates of *A* are (10,000.000, 5,000.000).

17.27* Clockwise horizontal angle = 55°37'42", zenith angle 92°34'18", slope distance = 435.09 ft, *hr* = 6.00 ft.

(10,381.31, 4791.38, 1190.17)

Az	H-Dist	V-Dist	x	y	H
118°41'00"	434.65	-19.52	10,381.31	4,791.38	1190.17

17.28 Clockwise horizontal angle = 272°42'22", zenith angle = 92°28'16", slope distance = 158.90 ft, *hr* = 5.83 ft.

(9934.83, 5144.76, 1203.01)

Az	H-Dist	V-Dist	x	y	H
335°45'40"	158.75	-6.8511	9934.826	5144.76	1203.009

17.29 Clockwise horizontal angle = 55°15'06", zenith angle = 88°35'24", slope distance = 203.02 ft, *hr* = 6.00 ft.

(10,178.69, 4903.76, 1214.69)

Az	H-Dist	V-Dist	x	y	H
118°18'24"	202.96	4.9956	10178.69	4903.76	1214.686

17.30 Clockwise horizontal angle = 307°56'52", zenith angle = 87°17'40", slope distance = 304.90 ft, *hr* = 6.00 ft.

(10,058.13, 5298.96, 1224.08)

Az	H-Dist	V-Dist	x	y	H
11°00'10"	304.56	14.392	10058.13	5298.96	1224.082

17.31 Describe how the arbitrary coordinates of a point cloud are transformed into a conventional coordinate system.

From Section 17.9.5, paragraph 3: "The original point cloud has coordinates in an arbitrary three-dimensional coordinate system. If it is necessary to have coordinates in a project-based coordinate system, a traditional survey can be used to establish coordinates on targets in the scene. Control must be strategically located at the edges of each scene. A minimum of three control points per scene is required. However, additional control is often used to provide redundancy. Multiple scenes can be connected using common control targets. After determining the project coordinates of the control, a three-dimensional conformal coordinate transformation discussed in Section 17.10, is performed to transform points from the arbitrary coordinate system to the project coordinate system."

17.32 List various equipment used for making hydrographic depth soundings, and discuss the limitations, advantages, and disadvantages of each.

From Section 17.13: Sounding pole, lead lines, or echo (depth) sounder.

17.33* On a map having a scale of 200 ft/in. the distance between plotted fixes 49 and 50 of Figure 17.14 is 3.15 in. From measurements on the profile of Figure 17.13, determine how far from fix 50 the 20-ft contour (existing between fixes 49 and 50) should be plotted on the map.

0.47 in. Ratio between fixes 49 and 50 = 0.15. Solution = 0.15*3.15 = 0.47 in.

17.34 Similar to Problem 17.33, except locate the 16-ft contour between fixes 50 and 51 if the corresponding map distance is 2.98 in.

2.12 in. Ratio = 0.71 in. Solution = 0.71(2.98) = 2.12 in.

17.35 Why is it important to show the shoreline and some planimetric features for navigation hydrographic maps?

Navigators, fisherman, and others can visually locate their position using references to shoreline features.