INTRODUCTION TO TOPOGRAPHIC MAPS

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All of the following questions refer to the Monmouth, OR Quadrangle.

1) What is the fractional scale, contour interval, and magnetic declination of this map?
   a) Scale: 
   b) Contour Interval:  
   c) Declination: 

2) What quadrangle maps are located immediately adjacent to the Monmouth Quad.?
   a) North:  
   b) South:  
   c) East:  
   d) West: 

3) What is the quadrangle size series of this map (in long. and lat.)?

4) What is the date of publication of this map?

5) What does the tick with 4956000m N. mean? (lower right of map)

6) What is the name of the major fluvial system flowing through this area. Of What larger drainage basin(s) does this river form a part of?

7) What is the approximate elevation of the Natural Sciences Building based on the map representation?

8) Given the fractional scale determine the following

   5 inches on the map= _______ Feet on ground = _______ Miles on ground.
   10 inches on the map= _______ Meters on ground = _______ Kilometers on ground.

9) A. What is the road distance in miles along Rt. 99 between Helmick State Park and Monmouth city limits?
   B. What is the distance in kilometers?

10) A. Determine the average stream gradients (in Ft/Mi) for the following drainages:

     A. Willamette River:  Gradient:  Length:
     B. Luckiamute River:  Gradient:  Length:

11) A. What is the highest point of elevation represented on this map?
    B. What is the lowest point of elevation represented on this map?
    C. What is the maximum relief.

12) A. What is the longitude and latitude location of the road intersection at Buena Vista
    B. What is the longitude and latitude location of Davidson Hill?
    C. What is the straight line distance in miles between these two points?
D. What is the azimuth bearing FROM Davidson Hill TOWARDS Buena Vista?

E. What is the quadrant bearing FROM Buena Vista TOWARDS Davidson Hill?

13) A. What is the nature of the topographic slope in the vicinity of the town of Monmouth?

C. What is the local relief between WOU and the Willamette adjacent to Independence?

D. Is the outline of the topography east of Independence relatively arcuate or irregular in outline?

E. What processes might have formed the pattern in D above?

14) Examine the cultural activity immediately north of Monmouth and Independence.

A. Write a brief assessment of the potential for environmental degradation to the surface and groundwater of this area. List three types of water quality degradation (i.e. contamination) problems that may exist in this area.

18. Determine the elevations of the following locations:
   A. Wigrich
   B. Oak Hill (SC)
   C. Dicker Reservoir (NE)
   D. Davidson Bridge (SC)

19. Draw a topographic profile along a line connecting Oak Hill (SC) to Vitae Springs. Use a horizontal scale of 1 in = 4000 Ft, and a vertical scale of 1 in = 333.33 ft (see attached profile paper).

   A. Determine the minimum slope grade represented on the profile in percent.

   B. Determine the maximum slope grade represented on the profile in percent.

   C. Where are the areas most likely associated with flooding?

   D. The vertical exaggeration of a profile is calculated by: $VE = \frac{H \text{ scale}}{V \text{ scale}}$; Calculate the vertical exaggeration represented on the attached profile.
Topographic Profile from Oak Hill to Vitae Springs, Monmouth, OR Quad.

Horizontal Distance in Feet (each tic = 2000 ft)

Horizontal Scale: 1 in = 4000 ft
Vertical Scale: 1 in = 333.33 ft

V.E. = H/V =

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used to discover changes on the landscape, and the changes are overprinted on the maps in a standout color (blue, purple, red, or gray).

**Contour Lines**

Examine the image of one of the Galapagos Islands in Figure 54, a perspective view of the landscape that has been false colored to show relief. It was made by transmitting imaging radar from an airplane flying at a constant altitude. Timed pulses of the radar measured the distance between the airplane (flying at a constant elevation) and the ground. Overlapping pulses of the radar produced the three-dimensional perspective similar to the way that overlapping lines of sight from your eyes enable you to see in stereo. Notice that the island has a distinct coastline, which has the same elevation all of the way around the island (zero feet above sea level). Similarly, all points at the very top of the green (including yellow-green) regions from a line at about 300 feet above sea level. These lines of equal elevation (i.e., the coastline and 300 foot line) are called **contour lines**. Unfortunately, the 1200-ft contour line (located at the boundary between yellow and pink) is not visible below the David and Walls Volcanoes in this perspective view. The only way that you could see all of the 0, 300, 700, and 1200-ft contour lines at the same time would be if you viewed

![Diagram of Earth's geographic grid and coordinate system.](image)

**Figure 51** Latitude and longitude geographic grid and coordinate system. Earth’s spherical surface is divided into lines of latitude (parallels) that go around the world parallel to the Equator, and lines of longitude (meridians) that go around the world from pole to pole. There are 360 degrees (360°) around the entire Earth, so the distance from the Equator to a pole (one-fourth of the way around Earth) is 90° of latitude. The Equator is assigned a value of zero degrees (0°) latitude, the North Pole is 90 degrees North latitude (90° N), and the South Pole is 90 degrees south latitude (90° S). The prime meridian is zero degrees of longitude and runs from pole to pole through Greenwich, England. Locations in Earth’s Eastern Hemisphere are located in degrees east of the prime meridian, and points in the Western Hemisphere are at located in degrees west of the prime meridian. Therefore, any point on Earth can be located by its latitude-longitude coordinates.

The latitude coordinate of the point is its position in degrees north or south of the Equator. The longitude coordinate of the point is its position in degrees east or west of the prime meridian. For example, point A is located at coordinates of 20° North latitude, 130° West longitude. For greater detail, each degree of latitude and longitude can also be subdivided into 60 minutes (60′), and each minute can be divided into 60 seconds (60″). Note that a 15-minute (1/4) quadrangle map represents an area of Earth’s surface that is 15 minutes of longitude wide (E-W) and 15 minutes of latitude long (N-S). A 7.5-minute quadrangle map is one-fourth of a 15-minute quadrangle map.
1. Every point on a contour line is of the exact same elevation; that is, contour lines connect points of equal elevation. The contour lines are constructed by surveying the elevation of points, then connecting points of equal elevation.

2. Interpolation is used to estimate the elevation of a point B located in line between points A and C of known elevation. To estimate the elevation of point B:

\[
\begin{align*}
A & = 100 \\
B & = 200 \\
C & = 300 \\
\end{align*}
\]

Interpolate B = 200 halfway to 100 
Interpolate B = 300 halfway to 100

3. Extrapolation is used to estimate the elevations of a point C located in line beyond points A and B of known elevations. To estimate the elevation of point C, use the distance between A and B as a ruler or graphic pen guide to estimate the line to elevation C:

\[
\begin{align*}
A & = 100 \\
B & = 400 \\
C & = 500 \\
\end{align*}
\]

Imagine a straight line parallel between A and B, extend equally in line to estimate C.

4. Contour lines always separate areas of higher elevation (uphill) from points of lower elevation (downhill). You must determine which direction, on the map is higher and which is lower relative to the contour line in question, by checking their elevations.

5. Contour lines always close to form an irregular circle. But sometimes part of a contour line extends beyond the mapped area so that you cannot see the entire circle formed.

6. The elevation between any two adjacent contour lines of different elevation on a topographic map is the contour interval. Often, every fifth contour line is thicker so that you can count by five lines the contour interval. These thicker contour lines are known as index contours, because they generally have elevations printed on them.

7. Contour lines never cross each other except for one case: where an overhanging cliff is present. In such a case, the hidden contours are dashed.

8. Contour lines can merge to form a single contour line only where there is a horizontal cliff or wall.

9. Equally spaced contour lines of different elevation represent a uniform slope.

10. The closer the contour lines are to each other the steeper the slope. In other words, the steeper the slope the closer the contour lines.

11. A series of closed contours represents a hill:

12. Depression contours have hachure marks on the downhill side and represent a closed depression:

See Figure 9.8

13. Contour lines form a V pattern when crossing streams. The apex of V always points upstream (uphill):

Agape (tip) of the V

downstream (downhill)

14. Contour lines that occur on opposite sides of a valley or ridge always occur in pairs. See Figure 9.9.

FIGURE 9.6 Rules for constructing and interpreting contour lines on topographic maps.
Each having an area of 1 square mile (640 acres). These squares are called sections.

Sections are numbered from 1 to 36, beginning in the upper right corner (Figure 9.11B). Sometimes these squares are shown on topographic quadrangle maps (Figure 9.3, red grid). Any point can be located precisely within a section by dividing the section into quarters (labeled NW, NE, SW, SE). Each of these quarters can be subdivided into quarters and labeled (Figure 9.11C).

GPS—Global Positioning System

The Global Positioning System (GPS) is a constellation of 24 navigational communication satellites in 12-hour orbits approximately 12,000 miles above Earth (about 34 of these are operational at any given time). The GPS constellation is maintained by the United States (NOAA and NASA) for operations of the U.S. Department of Defense, but it is free for anyone to use. Since GPS receivers can be purchased for as little as $100, they are widely used by airplane navigators, automated vehicle navigation systems, ship captains, hikers, and scientists to map locations on Earth. More expensive and accurate receivers with millimeter accuracy are used for space-based geodetic measurements that reveal plate motions over time (Laboratory 2).

Each GPS satellite communicates simultaneously with fixed ground-based Earth stations and other GPS satellites, so it knows exactly where it is located relative to the center of Earth and Universal Time Coordinated (UTC, also called Greenwich Mean Time). Each GPS satellite also transmits its own radio signal on a different channel, which can be detected by a fixed or handheld GPS receiver. If you carry a handheld GPS receiver in an unobstructed outdoor location, then the receiver immediately acquires (picks up) the radio channel of the strongest signal it can detect from a GPS satellite. It downloads the navigational information from that satellite channel, followed by a second, third, and so on. A receiver must acquire and process radio transmissions from at least four GPS satellites to triangulate a determination of its exact position and elevation (Figure 2.2) — this is known as a fix.

Most newer models of GPS receivers are 12 channel parallel receivers, which means they can receive and process radio signals from as many as twelve satellites at the same time (though you might not receive signals from all twelve satellites). Older models cycle through the channels one at a time, or have fewer parallel channels, so they take longer to process data and usually give less accurate results. An unobstructed view is also best, because GPS receivers cannot operate indoors. If the path from satellite to receiver is obstructed by trees, canyon walls, or buildings, then the receiver has difficulty receiving that radio signal. It is also possible that more or fewer satellites will be nearly overhead at one time than another, because they are in constant motion within the constellation. Therefore, if you cannot obtain a fix at one time (because there are not four visible satellites), you may still be able to obtain a fix in another half hour or so. Acquiring more than four satellites makes it possible to use navigational data and more accurate results. Most handheld, 12-channel parallel receivers have an accuracy of about 10-15 meters.

When using a GPS receiver for the first time in a new region, it generally takes about one to three minutes for it to triangulate a fix. This information is stored in the receiver, so readings taken over the next few hours at nearby locations normally take only seconds. Consult the operational manual for your receiver so you know the time it normally takes for a cold fix (first time) versus warm fix (within a few hours of the last fix).

GPS navigation does not rely on a latitude-longitude datum of the public land survey system. It relies on an Earth-centered geographic grid and coordinate system called the World Geodetic System 1984 (WGS 84) or WGS 84. WGS 84 is a datum (survey or navigational framework) based on the Universal Transverse Mercator (UTM) grid described below.

UTM—Universal Transverse Mercator System

The U.S. National Imagery and Mapping Agency (NIMA) developed a global military navigation grid and coordinate system in 1947, called the Universal Transverse Mercator System (UTM). Unlike the latitude-longitude grid that is spherical and measured in degrees, minutes, seconds, and decimal miles (a naval mile = 1 minute of latitude), the UTM grid is rectangular and measured in decimal-based metric units (meters).

The UTM grid (top of Figure 9.12) is based on sixty north-south zones, which are strips of longitude having a width of 6°. The zones are consecutively numbered from Zone 01 (between 1°W and 179°W) to Zone 60 (between 174°E and 117°E east longitude) at the eastern margin of the grid. The location of a point within a zone is defined by its easting coordinate — its distance from the central meridian of the zone to east, and a northing coordinate — its distance from the Equator measured in meters. In the Northern Hemisphere, northing is given in meters north of the Equator. To avoid negative numbers for northing in
FIGURE 3.12 UTM and GPS. A handheld Global Positioning System (GPS) receiver, operated at point K, indicates its location according to the Universal Transverse Mercator (UTM) grid and coordinate system. North American Datum 1983 (NAD83). Refer to text for explanation.
the Southern Hemisphere, NIMA assigned the Equa-
for a reference meridian of 10,000,000 meters.
Since satellites did not exist until 1957, and GPS
government satellites did not exist until decades later, the
UTM grid was applied for many years using re-
gional ground-based surveys to determine locations of
the grid boundaries. Each of these regional or con-
tinental surveys is called a datum and is identified on
the basis of its location and the year it was surveyed.
Examples include North American Datum 1927
(NAD27) and North American Datum 1983
(NAD83), which appear on many Canadian and U.S. Geological
Survey topographic quadrangle maps. The Global Pos-
sitioning System relies on an Earth-centered UTM
datum called the World Geodetic System 1984 or WGS
84, but GPS receivers can be set up to display regional
datums like NAD27. When using GPS with a topo-
graphic map, be sure to set the GPS receiver to dis-
play the UTM datum of that map.

Study the illustrations of a GNS receiver in Figure
9.12. Notice that the receiver is displaying UTM coor-
dinates (based on NAD27) for a point X in Zone 18 (north
of the Equator). Point X has an easting coordinate of
340,033, which means that it is located 340,033 meters
east of the starting (west) edge of Zone 18. Point X also
has a northing coordinate of 465,120, which means that it is
located 465,120 meters north of the Equator. Therefore,
Point X is located in southeast Pennsylvania. To plot Point X:

1. Draw a 1,000-meter scale, 7.5 minute topo-
graphic quadrangle map, see Figure 9.13.

2. Point X is located within the Limits, PA 7.5' M
Quadrangle Series (LC69, 1:24,000 scale) topographic
quadrangle map (Figure 9.13). Information printed on the
map margin indicates that the map has blue ticks spaced
1,000 m apart along its edges that conform to NAD27.
Zone 18. Notice how the ticks for northings (blue) and
eastings (green) are represented on the northwest cor-
er of the large map—Figure 9.13. One northing
label is written out in full (340,033 m) and one east-
ing label is written out in half (465.12 m), but the
other values are given in UTM shorthand for thou-
sands of meters (i.e., do not end in .000 m). Since Point X
has an easting of 340,033 within Zone 18, it must be
located 333 m east of the tick mark labeled 340,000 m
along the top margin of the map. Since Point X has a
northing of 465,120, it must be located 250 m north of
the tick mark labeled 465 in UTM shorthand.
Examples of UTM Grids

To determine a compass bearing on a map, draw a
straight line from the starting point to the destina-
tion point and also through any one of the map’s bor-
ders. Align the protractor (left drawing, Figure 9.14) or
the N-S or E-W directional axis of a compass (right
drawing, Figure 9.14) with the map’s border, and read
the bearing in degrees toward the direction of the
destination. Imagine that you are buying a property for
your dreams home. The boundary of the property is
marked by your would-be roads drawn into the ground.
A. Map margin

Produced by the United States Geological Survey in cooperation with Commonwealth of Pennsylvania agencies.


North American Datum of 1927 (NAD 27). Projections and 10,000 foot ticks: Pennsylvania coordinate system, south zone Lambert conformal conic.

Blue 1:100,000 meter Universal Transverse Mercator ticks, zone 18.

North American Datum of 1983 (NAD 83) is shown by dashed corner ticks. The values of the shift between NAD 27 and NAD 83 for 7.5-minute quadrangles are obtainable from National Geodetic Survey NADCON software.

There may be private holdings within the boundaries of the national or State reservations shown on this map.

FIGURE 9.13 UTM and topographic maps—refer to text for discussion. Point X (from Figure 9.12) is located within the Lillitz, PA 7(2) Metric Series (USGS, 1:24,000 scale) topographic quadrangle map. A. Map margin indicates that the map includes UTM grid data based on North American Datum 1927 (NAD27, Zone 18) and represented by blue ticks spaced 1000 meters (1 km) apart along the map edges. B. Connect the blue 1000-m ticks to form a grid square, each representing 1 square kilometer. Notches (suit) are read along the N-S map edge, and headings (green) are located along the E-W map edge. C. You can construct a 1 km grid (1:24,000 scale) from the map’s bar scale, then make it transparently off of it to form a grid overlay (see GeoTools Sheet 3 at back of manual). Place the grid overlay atop the 1-kilometer square on the map that includes point X, and determine the NAD27 coordinates of X as shown (not).
FIGURE 9.31 Topographic profile construction and vertical exaggeration. Shown are a topographic map (Step 1), topographic profile constructed along line A-A' (Steps 2 and 3), and calculation of vertical exaggeration (Step 4). Step 1—Select two points (A, A'), and the line between them (line A-A'), along which you want to construct a topographic profile. Step 2—To construct the profile, the edge of a strip of paper was placed along line A-A' on the topographic map. A tick mark was then placed on the edge of the paper at each point where a contour line and stream intersected the edge of the paper. The elevation represented by each contour line was noted at its corresponding tick mark. Step 3—The edge of the strip of paper (with tick marks and elevation numbers) was placed along the bottom line of a piece of lined paper, and the lined paper was graduated for elevations (along its right margin). A black dot was placed on the profile above each tick mark at the elevation noted on the flow mark. The black dots were then connected with a smooth line to complete the topographic profile. Step 4—Vertical exaggeration of the profile was calculated using either of two methods. Thus, the vertical dimension of this profile is exaggerated (stretched) to 19.7 times greater than it actually appears in nature compared to the horizontal map dimension.