Topographic Maps   Name ______________________________
Self-Instruction Lab   Geology 100   David Harbor's Section

Topographic maps are an important aid for a geologist, but maps are also useful for hikers, bicyclists, and others at large in the landscape. In two dimensions, they portray the topography (the spatial change in elevation) of an area as well as other geographic information. It is important for you to learn the types of information that can be obtained from a topographic map, how to locate features and show direction, and how to translate mentally the information on the map into an image of the landscape. This lab introduces you to the information on a map and different methods of location.

Most of the topographic maps of the U.S. are issued by the U.S. Geological Survey. At the turn of the century they were made from field surveys. Later they were constructed by hand from aerial photography, then using computers to derive topography. We now get topographic data from satellite radar interferometry. The "terrain" in Google maps is based on those data, which are available globally.

Map Scale

The scale of a map is determined by the area that it covers. A "small scale" map covers a large area (Lexington appears "small" on a map of Virginia) whereas a "large scale" map covers a smaller area in greater detail (Lexington appears "large" on a street map of Lexington). Always select a map that is appropriate for your task. The scale of a map is identified in two ways at the bottom margin; a **fractional scale** (e.g., 1:24,000) and a **graphical scale**. The graphical scale (below) is easily used with a ruler or a slip of paper.

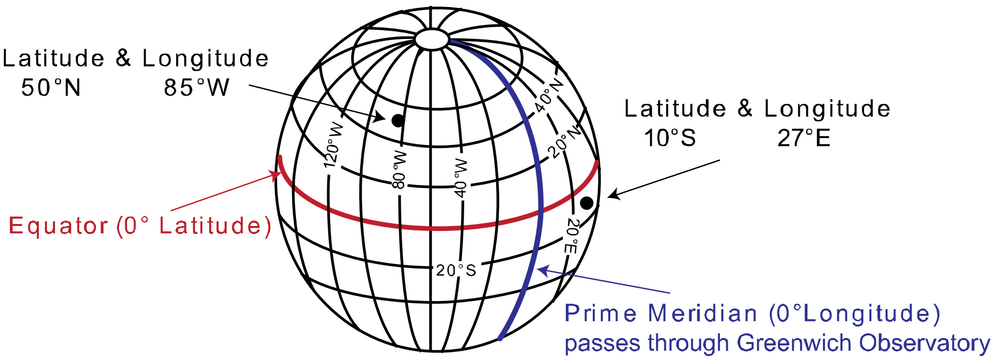
A fractional scale of 1:24,000 means that at distance of one centimeter on the map equals a distance of 24,000 centimeters on the ground. Common map scales are 1:250,000 (small), 1:100,000, 1:62,500, 1:24,000 (large). To determine distance, measure the distance between two points using a ruler and then convert to a common or usable number (for example, you probably don't want to know how far it is to Roanoke *in inches*).

For example: What distance is represented by 22 inches on a 1:62,500 scale map?

$$22\ map\ in\ \ x\ \ \frac{62{,}500\ \ in}{1\ \ map\ \ in}\ \ x\ \ \frac{1\ \ ft}{12\ \ inches}\ \ x\ \ \frac{1\ \ mile}{5280\ \ ft}\ \ =\ \ 21.7\ \ miles$$

If a map is photocopied at a different scale by enlarging or reducing, the ratio scale will be incorrect but the graphical scale will remain correct.

Questions
1. What is the scale of the old Lexington VA map? and the new one? (the date is below the name in the margin) Which map is the *larger scale* map?
2. Using the graphical scale, determine how many miles to the inch on the Point Reyes CA map. What is the scale?
3. Cumberland,MD-PA-WV: Using the ratio scale and measurements in centimeters, determine the width (in km) of Wills Mountain at "the Narrows" west of Cumberland. Show calculations.



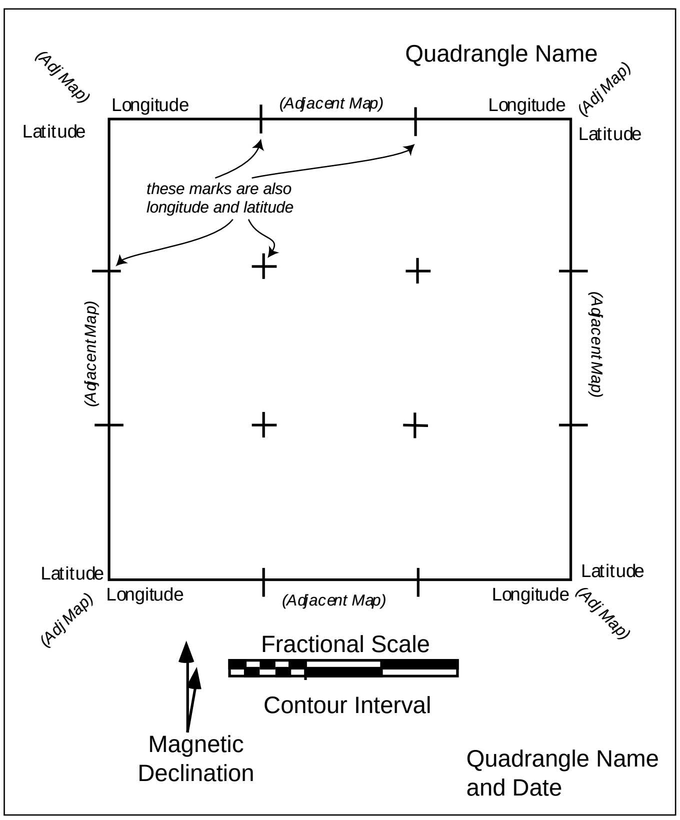
Map Location

Latitude and Longitude

Latitude is indicated by east-west lines parallel to the equator (called "parallels") and is measured in degrees north and south of the equator (up to 90°N or S). Lines of equal **longitude** are called meridians and connect the north and south poles. Longitude is measured in degrees east and west (up to 180°E or W) the **prime meridian**, through the Royal Observatory in Greenwich, England. The latitude and longitude of the parallels and meridians that make up the map borders are marked at the four corners of the map in **degrees** (°)**, minutes** (60' per degree), and **seconds** (60" per minute) as shown below.

USGS topographic maps are named by the range of latitude and longitude the map covers. Small scale maps (1:250,000) cover 1° latitude and 2° longitude. Common USGS map are 1:100,000-scale (30'x60') maps, 1:62,500 (generally older maps called "15 minute") **quadrangles**, and the most detailed 1:24,000 ("7.5 minute") quadrangles.

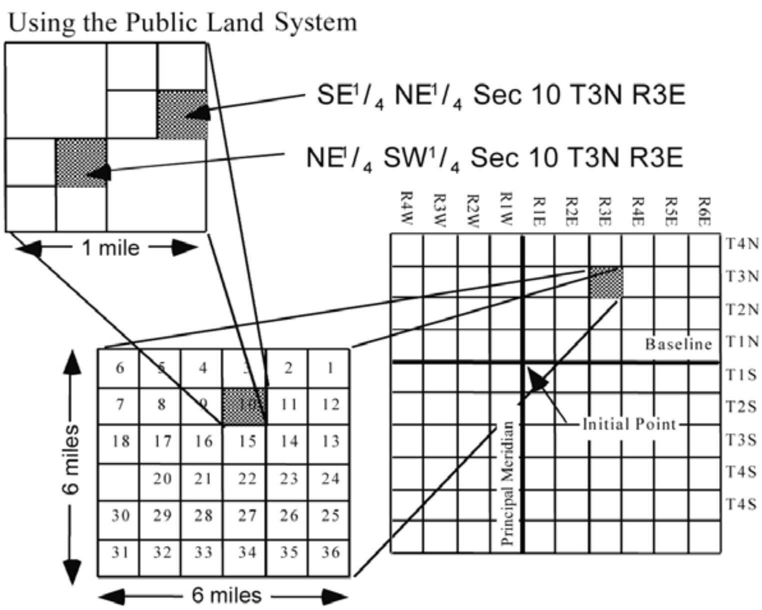
USGS Topographic Quadrangle Marginalia



Each side of a 1:24,000 map is broken into thirds and the latitude or longitude is given. Use the latitude and longitude to locate any point on a map by giving the latitude and longitude to the nearest degree, minute, or second, such as for the Lexington Post Office at 37°47'06"N 79°26'43" W.

A map can also be broken up into "ninths" using these marks and locations can be given as the NE–Lexington Quad or C– Buena Vista Quadrangle.

NW	NC	NE
CW	C	CE
SW	SC	SE



Public Land Survey

Another common method of location west of the Appalachian Mountains is the system referred to as the **Public Land Survey**, originally conceived and initiated to assist the settling of the country during the period of homesteading. An Initial Point was selected for a region (states and territories) and East-West parallels and North-South meridians were surveyed at 6 mile intervals. Each square is called a **township** and is designated by a **Township Number** north and south of the **Baseline** and a **Range Number** east and west of the **Principal Meridian**. Because this is a "square" grid and meridians converge toward the poles, corrections are made at regular intervals and bordering townships may be offset. Townships are also offset at the boundaries between the different surveys. Townships are divided into 36, 1-mile-square **Sections** and are numbered as indicated. Locations given with a section are by quarters and quarters of quarters. In referring to a location, start small and work big, finishing with the quadrangle name if necessary. The lines, section numbers, and township/range information is printed in red. ***The township and range (N and S or E and W) are along the margins of the map near the center of the 6 mile by 6 mile square, often in red.***

4. What is the latitude of the southwest corner of the Lexington Quadrangle (use either new or old)?

5. What is the approximate latitude and longitude of W&L to the nearest minute (use either map)?

6. What is located in section 21, T20N R28E of the Moses Lake Quadrangle?

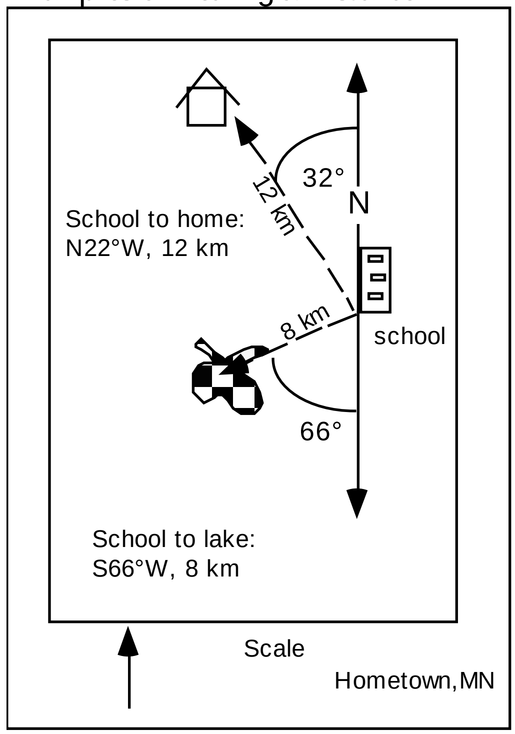
7. Locate the hospital in Moses Lake to the nearest quarter section using the public land survey system.

8. What prominent feature is located in the SC ninth of the Moses Lake map?

Direction

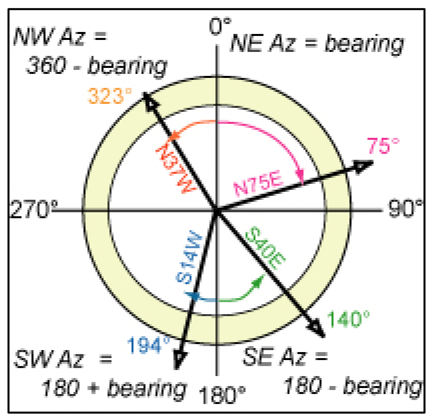
Magnetic north is ***not*** located at the north pole, it's about 5 degree south at 150°W longitude, and heading north fast! Compass readings must be adjusted for this difference. The direction and amount of difference between true north and magnetic north is called the **Magnetic Declination**. This information is located at the bottom of all topographic maps. Look at the Lexington 7½ minute quadrangle; magnetic north is 5.5° or 8.5°W of true north (depending on the time it was printed). *For Fall 2016, the magnetic declination is 9° 4'(± 21') W changing by 0° 2' W per year* (source: http://www.ngdc.noaa.gov/geomag-web/#declination).

Examples of Bearing & Distance



Direction is one of two pieces of information necessary to describe the relative location of two points; **Bearing and Distance.** Bearing describes the angle between a line drawn from the starting point to the ending point and true (or magnetic) north. It is given in 4 quadrants (NE, NW, SE, SW) and using angles from 1° to 89°. Using the example, the house is northwest of the school and the angle between true north and the bearing line is 32 degrees. So the bearing is N32°W. The distance is computed using the ratio scale or measured using the graphical scale.

How does one determine the angle of bearing line relative to a N-S line? Lay a ruler along the bearing line allowing it to intersect the edge of the map. Then measure the angle from north or south using a protractor. Remember to start with 0° to the south when working the southwest and southeast quadrants.



9. What is the magnetic declination of the Cumberland map?

10. and the Point Reyes Map? (GN refers to "Grid North" which we're not using)

11. Using a ruler and protractor determine the bearing and distance from the lighthouse on Point Reyes (SW) to Point Reyes Hill (38°04'N, 122°52'W).

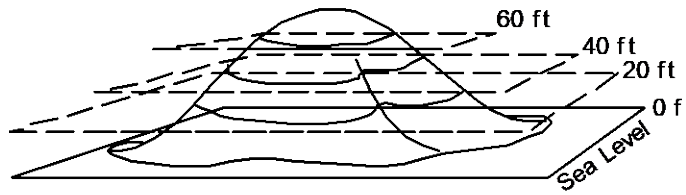
Topography

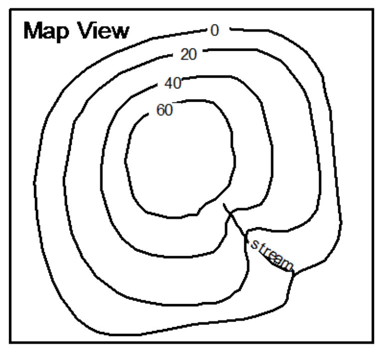
The elevation information on a topographic map is represented by **spot elevations**, which are printed individually on the map, and by **contour lines**. Contour lines connect points of equal elevation. Imagine yourself walking along the side of a hill but neither gaining nor losing elevation: you are "walking the contour of the land." The difference in elevation between adjacent contour lines is the **contour interval**. The elevation of every 5th contour line, a thicker line known as the **index contour**, is printed on the contour. The contour interval is always given at the bottom of a topographic map near the scale.

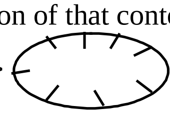
Visualizing Topographic MapConstruction

RULES FOR CONTOUR LINES

1. All points on a contour line have the same elevation.
2. Contour lines never cross, divide, or split. They *may* appear to merge at vertical cliffs.
3. A contour line will eventually close back on itself, given enough map, because they never just stop. Imagine walking along the water's edge on the shore of the eastern U.S. Going in one direction, you would get back to your starting point but you will have walked completely around North and South America!
4. All points inside a closed contour line are higher than the elevation of that contour.
5. All points within closed **hachured** contour lines are lower than the elevation of that contour.





A hachured contour line --->  indicates closed depressions

6. Contours that cross streams and rivers make a V that points upstream.

12. What is the contour interval of the Lexington Quadrangle? (**use the 15' quadrangle, 1:62,500 scale map**)

13. Using this old Lexington topographic map, give the spot elevation for of Jump Mountain (NW).

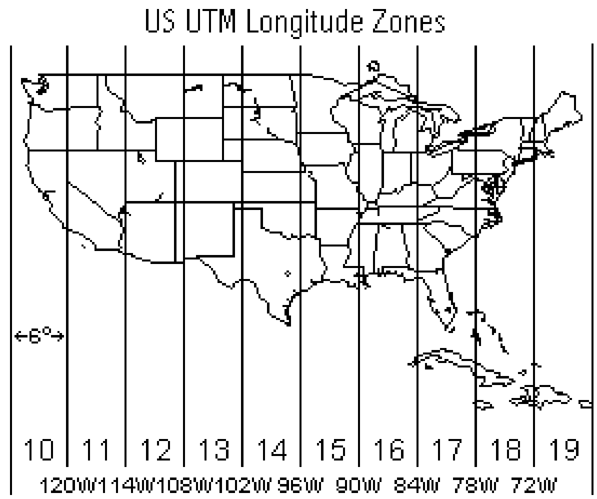
14. What type of contour surrounds the WREL radio tower north of Rte 11, north of East Lexington (now use the 1:24,000 map)? What elevation is the base of the tower?

15. Which side of the Maury River north of Lexington is steeper? How did you determine this?

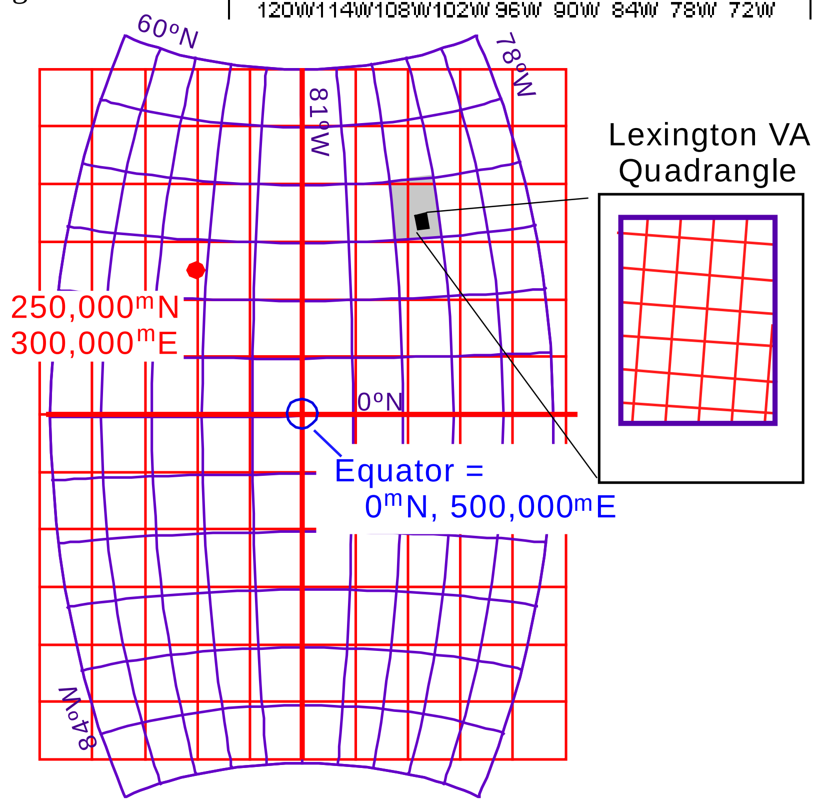
16. Using only the "v" of the contour lines, state the flow direction of Union Creek in the very SW corner of the Lexington 1:24,000 map (the newer 1:24k, Lexington quad).

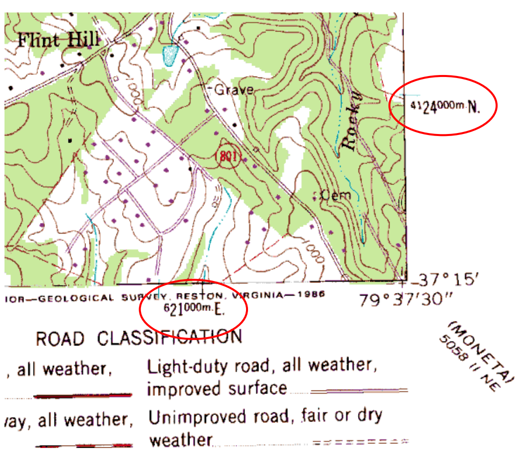
Universal Transverse Mercator

A new form of location often used in GPS is a "cylindrical" projection of the round earth onto a cylinder wrapped around the globe. The military developed a Transverse "Mercator" (dead white male who liked cylindrical projections) 3d to 2d transformation known as the "Universal Transverse Mercator" or UTM projection. In UTM, 6 degree slices of the earth extend from 84ºN to 84ºS. In western Virginia, we're in the 6º slice (Grid Zone 17) that extends between 78 and 84 degrees West of Greenwich (image from http://www.kimdara.com/usaphotomaps/), and is centered on 81 ºW. So-called "grid zones" are counted west to east starting from 180º on the globe.



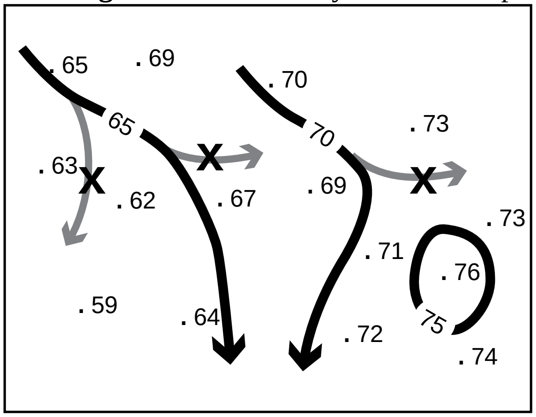
The coordinate system is based on meters North of the equator (up here anyway) and distance East, known as the "northing" and "easting." The "zero" or "origin" of the UTM system is set at the central meridian (in our case 81º**)** at the equator. The meter units at the "origin" are 0 m North and 500,0000 m East. This is done to avoid going negative at the west edge of the zone. Distortion increases to the north and south away from the equator. On a topographic map, the UTM coordinates are shown abbreviated, except in the corners. Except for along the central meridian of the zone, UTM and lat-long are at angles to one another.





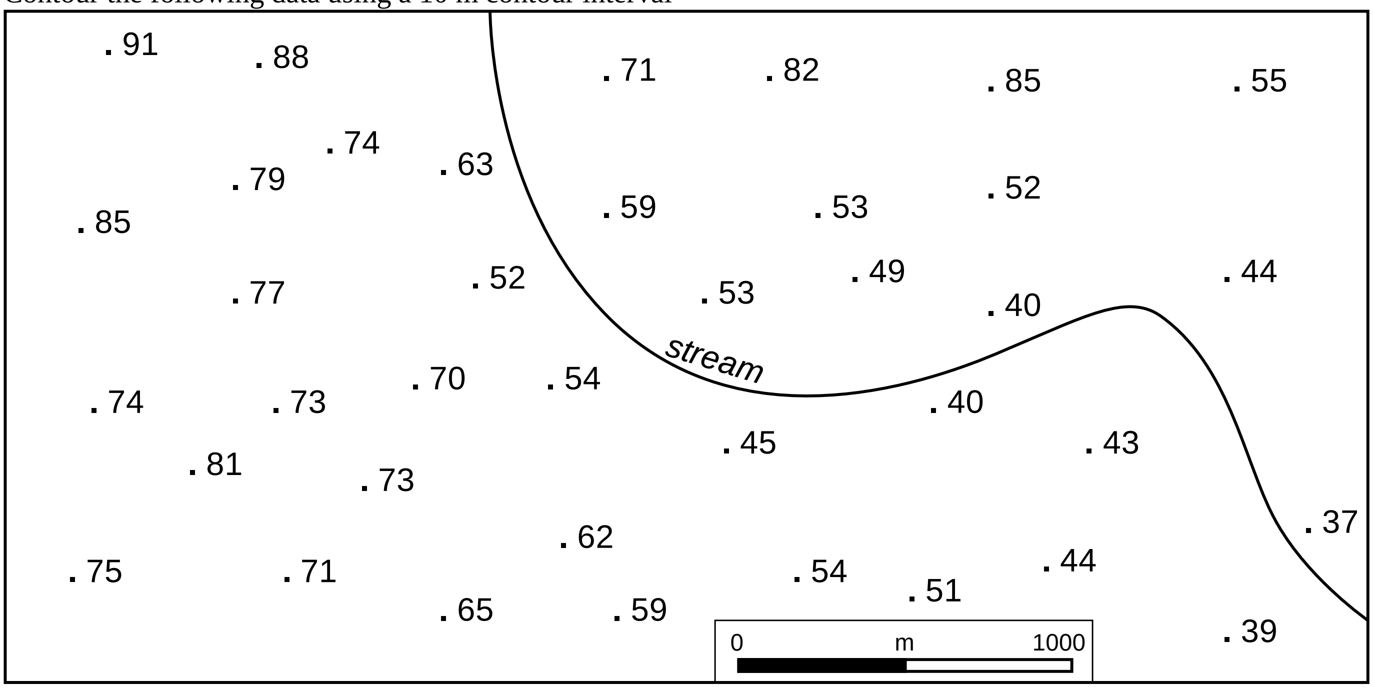
17. On a 1:24,000 Lexington Quadrangle (use the newer ones with UTM grid lines right on the map), what is located at 641,570^{m}E; 4,180,400^{m}N? And what is located at 632,450^{m}E; 4,190,400^{m}N?
18. On that same map, what are the UTM coordinates of Lee Chapel to the nearest 50 meters? (use a ruler or piece of scrap paper and the meters graphical scale to interpolate between the lines to the nearest 50 m or less)

Drawing Contour Lines – you will attempt to make one given “spot” elevations on the ground



- here I am using a contour interval of 5 m
- begin contours between two points or on a point that exactly corresponds to the contour
- continue the line where the contour elevation falls between adjacent points (65 goes between 62 & 67, but not between 62 & 63)
- more than one contour may go between points
- interpolate where the line goes between using the two values (the 65 line is closer to 67 than 62)
- circles enclose isolated highs or depressions
- draw smooth lines and label them
- contours cross streams as a “V”

Contour the following data using a 10 m contour interval



Topographic Slope

Elevation and relief are two different aspects of the topography. **<u>Elevation</u>** is the vertical distance above a datum, usually sea level. **<u>Relief</u>** is the difference between the highest and lowest points in a defined region (like a quadrangle). Relief and distance define the slope of the surface of the earth, which is expressed either in degrees, or **rise/run,** where **rise** is the elevation change and **run** is the horizontal distance. Multiply rise/run by 100 to get the gradient in percent.

$$slope\ (degrees) = tangent\left(\frac{rise\ (or\ \Delta elev)}{run(\ or\ \Delta dist)}\right) \ldots\ and \ldots\ gradient\ (\%) = \left[\frac{rise\ (or\ \Delta elev)}{run(\ or\ \Delta dist)}\right] \text{ x } 100$$

Closely spaced contour lines indicate a steep slope or gradient, whereas widely separated contour lines occur on gentle slopes.

19. On your contour map above, are the steepest slopes north or south of the river. How do you know? What is the gradient? (in percent)

Answers
1. old Lexington Quad = 1:62,500; new Lexington Quad = 1:24,000; the new map is the larger scale map
2. 1 mile to the inch, Scale = 1:62,500
3. $6\ map\ cm\ x\ \frac{24{,}000\ \ cm}{1\ \ map\ \ cm}\ \ x\ \frac{1\ \ m}{100\ \ cm}\ \ x\ \frac{1\ \ km}{1000\ \ km}\ =\ 1.44\ \ kilometers$
4. 37°45’ North
5. 37°47’ N 79°27’W
6. The airstrip at Larson Air Force Base.
7. NE1/4, Sec 23 T19N R28E
8. Potholes Reservoir
9. 6°West of true north (the east or west is very important!)
10. 17.5 °East
11. N55E (from true north), 16.4 km (or 10.3 miles).
12. 20 ft
13. 3139 ft at Jump Rock (this is also a benchmark location).
14. A depression (hachured) contour indicating the radio tower is less than 1020 ft.
15. The SW side, where the contours are closer together.
16. South; the “v’s” point north.
17. A gauging station on the Maury River. Kerrs Creek (the fire station :)
18. Lee Chapel is 637,150 ^{m}E, 4,183,200 ^{m}N.
19. The steepest section is north of the river between 52 and 85 m. The gradient there is approximately 33m/330 m x100 = 10 %