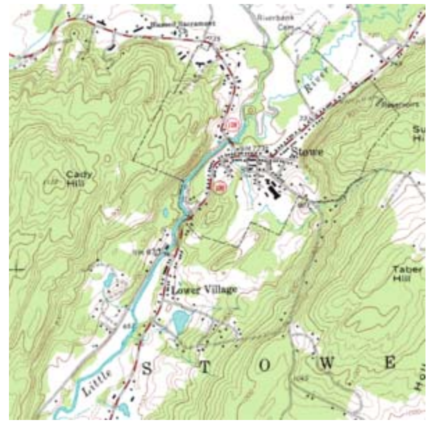
Lab 3: Topographic Maps 10 pts

Introduction



Topographic maps are one of the most important tools for studying landforms and the processes that shape them. These maps are two-dimensional, scaled representations of the Earth's surface that show the sizes, configurations, and spatial relationships of landforms and cultural features in great detail. They allow very accurate measurement of elevations and horizontal distances. The science of locating things on the earth's surface is called *geodesy*.

The advent of Global Positioning Systems (GPS) and Geographic Information Systems (GIS) has revolutionized the use of topographic and other maps by business, the scientific community and the public. MapQuest, Google Earth and auto GPS navigation systems are examples. These technologies require that the users have a basic understanding of map-making principles. This lab will focus on topographic maps, but many of the principles that apply to topographic maps are useful for interpreting maps in general.

GPS is a navigation systems based on the position of satellites in space. GPS receivers process signals from satellites in known positions and use triangulation to locate points on the Earth's surface. For example, some delivery services now keep track of the position of their trucks by using GPS technology, and ships at sea use it to determine if they are on course. Many people use GPS to locate themselves while hiking, fishing, etc. Geologists use very precise GPS measurements to keep track of motion along faults before and after earthquakes. This lab includes what you need to know about topographic maps so that they can be used in conjunction with a GPS receiver. GIS manages data acquired by GPS and other information on a digitized base map. It is a very powerful tool for analyzing spatial data.

Part 1: Basic facts about maps

USGS Topographic maps

This lab will focus on U.S. Geological Survey (USGS) topographic maps. Although they are published in a variety of formats (including digital), the most common printed maps are the 7.5 minute quadrangle series (aka "topo quads"). These maps are bounded by lines of latitude that are 7.5' apart (top and bottom boundaries of the map) and lines of longitude that are also 7.5' apart (east and west edges of the map). These maps are published at scales of 1:24,000 (1 inch = 2000 ft) or 1:25,000 (1 cm = 0.25 km). The detail they show is useful for geological mapping, engineering, local area planning and recreational purposes. It takes about 57,000 maps to cover the conterminous 48 states and complete 7.5' coverage is available for all states except Alaska. You can view interactive topo maps at web sites like http://www.topozone.com/.

Map Datum

All maps have a reference point from which the location of everything on the map is measured. This is referred to as the datum. (Datum is the singular form of the plural word "data".) The difference between common U.S. datums can be as much as 70 m. Before GPS, most map users were rarely concerned with the datum used for a particular map. However, GPS locations are determined from satellites in space, and in order for the receiver to be using the same coordinates as on the map, it must be told the datum. The vertical datum for elevation is usually mean sea level.

There are literally hundreds of choices of map datums for mapmakers to use. Map users in the US are most likely to encounter these:

- World Geodetic System 1984 (WGS 84) is a datum for the entire globe as defined by GPS
- North American Datum 1983 (NAD 83) is a new standard for US maps
- North America Datum 1927 Continental (NAD 27) was used for most US and Canadian maps currently in circulation

Map datum information is printed on most maps. On USGS topographic maps it may be found in the lower left-hand corner

Map Coordinate Systems

Depending on the task at hand, various methods are used for locating a position on a map. For example, you may locate a friend's house on a map by using the street address. However, this would not be a suitable technique for specifying the location of a mountain peak. For most geological applications, a positioning scheme that is independent of man-made features such as roads or political boundaries is more practical. Historically, the longitude and latitude grid has been used for this purpose. Another system in common use is the Universal Transverse Mercator (UTM) grid system. The UTM system is especially convenient for use with GPS receivers. Topographic maps produced by the USGS are prepared so that either latitude/longitude or UTM grids can be used.

Latitude & Longitude

Any point on earth may be uniquely described by its latitude and longitude.

The *latitude* of a point is its distance north or south from the equator measured in degrees of arc. The equator is 0 º latitude so the poles are 90º north and 90º south (Figure 1). The equator is a "great circle", that is, the largest circle you can draw on the earth's surface. "Lines" of longitude are actually circles that are parallel to the equator but that get smaller as you get closer to the poles (see Figure 1).

The *longitude* of a point is its distance east or west from the *Prime Meridian* in degrees of arc. The

Prime Meridian is an arbitrary starting point which passes through the Royal Naval Observatory in Greenwich, England. Lines of longitude are all great circles that encircle the globe in a north-south direction and pass through the poles (Figure 2). These lines are also called *meridians*. The prime Meridian is designated as 0° longitude. Other positions of longitude are measured as the number of degrees of arc they are to the east or west of the Prime Meridian. The “back-side” of the prime meridian is 180° east or west and is mostly coincident with the International Date Line.

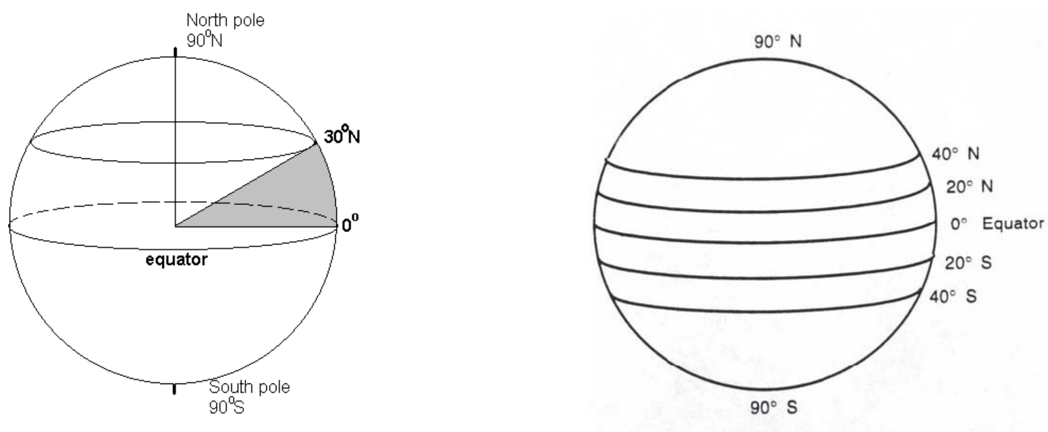


Figure 1: Latitude is the angle measured north and south from the equator. Latitude measures north/south but the lines run east/west.

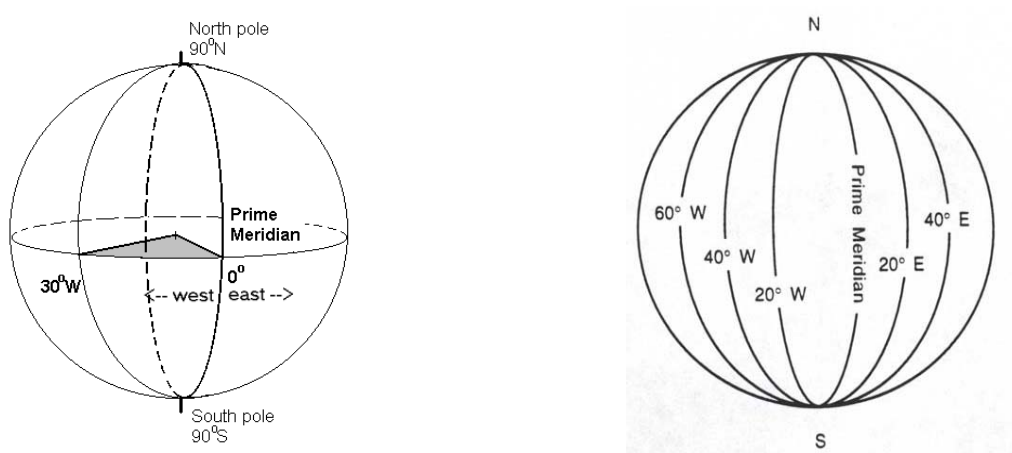


Figure 2: Longitude is the angle measured east or west from the Prime Meridian, an north-south line passing through Greenwich, England. Longitude measures east/west but the lines run north/south.

Coordinates are usually given in the form: latitude, hemisphere; longitude, hemisphere. For example, the position of Pasadena is about 34° North, 118° West, and the position of Sydney, Australia is about 34° South, 151° East.

One degree is about 69 miles or 110 km on the earth’s surface. To specify positions more precisely each degree of arc can be subdivided into 60 minutes (60’). Each degree can be further subdivided into 60 seconds (60”). In other words:

1º = 60’ and 1’ = 60”

For example, if you were giving the location of the Rose Bowl (instead of Pasadena generally), you would need to be more precise than “about 34º N, 118ºW”. The Rose Bowl 50 yard line is at 34º9’41”N, 118º10’0”W. Degrees of latitude and longitude may also be subdivided into decimal fractions. Using this method, the 50 yard line is 34.161ºN, 118.167ºW. (The Rose Bowl is a conspicuous feature on the Pasadena quadrangle map in the lab).

Where is North?

Most maps are printed with north at the top. This is true for all USGS 7.5 minute maps, which are also printed so that the east and west (left and right) boundaries are lines of longitude. However, if you are using a magnetic compass with a map, it is important to know that the compass needle does not point to true north. Instead, it points to magnetic north which is offset from the geographic north pole. The difference between the two is an angle called the magnetic declination (Figure 3). The magnetic declination is shown at the bottom of the maps by a diagram like Figure 4. In this diagram, magnetic north (MN) is 14º east of true north (shown by a star). It should be noted that magnetic declination varies not only from place to place but from year to year; therefore, all declination measurements include a date. Figure 4 also shows that grid north (GN, the orientation of the UTM grid lines) is 40’ west of true north.

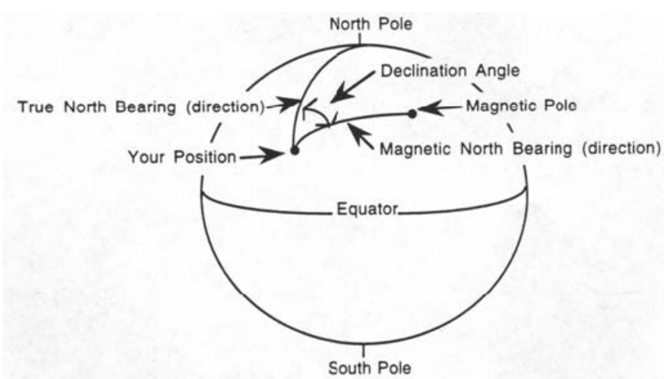


Figure 3. Magnetic map declination.

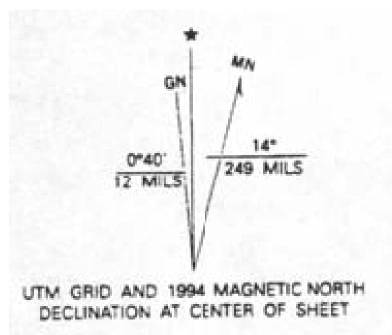


Figure 4. North arrows

Scale: How big are things shown on the map?

Map scales indicate how much larger features are in reality than they are on the map. There are two ways of indicating scale. One is a graphical scale where a bar graph indicates how long kilometers, miles, meters, or feet are on the map. The other is a ratio scale which is designated numerically either in fraction or ratio form. For example, the metric 7.5 minute scale can be expressed as 1/25,000 (fraction form) or 1:25,000 (ratio form). This indicates how much larger the distances are in reality than they are on the map. For example, at a scale of 1:25,000, a distance of

1 cm on the map would be 25,000 cm (or 250 m or 0.25 km) on the actual land depicted by the map. Many 7.5 minute quadrangles have not yet been converted to metric and they have a scale of 1:24,000.

Cultural and Natural features on topographic maps

Cultural features on topographic maps are shown in red, black, or purple. Light red shaded areas indicate regions of solid or almost solid construction and only landmark buildings are shown. Different classifications of roads are also indicated.

Natural features are shown in a variety of colors. Water (ocean, rivers, lakes, swamps) and ice (glaciers and snowfields) are shown in various blue patterns. Surface features (glacial moraines, sand dunes, mine dumps) are shown with brown patterns, and green patterns indicate different kinds of vegetation. Contour liens are shown in brown. Many of the standard symbols are shown in the flyer “Topographic Map Symbols” which is available in the lab.

How is topography indicated on maps?

Elevation and relief

Elevation is the vertical distance above or below some datum plane, normally taken as mean sea level (0 meters elevation). **Relief** is the difference in elevation between two points in a given region (usually the highest and lowest).

The best way to express elevation and differences in elevation is by means of contour lines. A **contour line** is a line of equal elevation. These are brown on the topo map. If you walked around a hill, never getting higher or lower you would be tracing a contour line. Therefore, contour lines never cross because one point cannot have two different elevations. They can, however, “bunch up” where the slope is very steep.

The concept of contour lines is best understood by imagining an island in the ocean (see figure 5). If you were to paint a brown line on the shoreline around the island you would create a contour line at mean sea level (0 m). All of the points are at the same elevation. If sea level rose 50 m, a new shoreline would result. You could paint a new line here where every point would have the same elevation (50 m above the original shore line). Now, imagine repeating this process, raising sea level 50-m each time, until the island was completely submerged. Finally, if the water level dropped back to it’s original position, the island would emerge covered with paint lines connecting points of equal elevation. These are contour lines. An aerial view of the island would be the equivalent of a contour or topographic map.

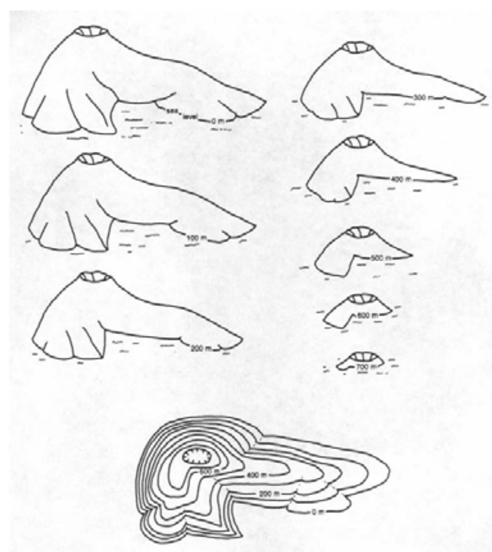


Figure 5

The vertical interval at which these contour lines are drawn is the contour interval. The contour interval of a topographic map shown in Figure 6 is 100 meters. On topographic map sheets, the contour interval is given on the lower margin of the map next to the scale. Usually, every 4th or 5th line is darkened and labeled to serve as a guide when determining elevation. If a point lies between two contours, *interpolate* to determine the elevation. However, bear in mind that contours are plotted to an accuracy of ½ one contour interval, so do not work needlessly on false accuracy.

The spacing of contour lines on a topographic map gives you clues about the slope of the surface. When contour lines are close together, such as the ones on the left end of the island in Figure 6, a steep slope is indicated. On the right end of the island, the contour lines are more widely spaced indicating a comparatively gentle slope.

Another characteristic of contour lines is that they "V" upstream. Notice on the island map in Figure 6 that the contour lines come to a point as they go across the streams (dashed lines).

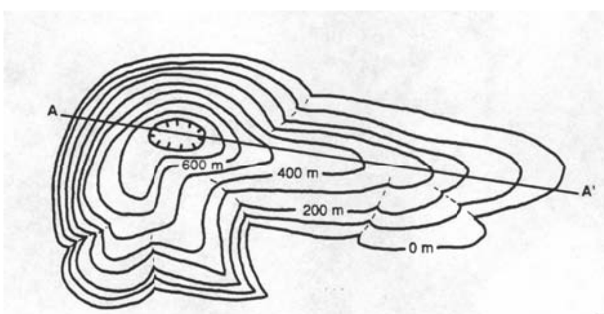
<u>Part II: Using Topographic Maps</u>

Topographic profiles

A topographic profile is a vertical section or side view through a portion of a topographic map that illustrates the shape of various landforms. It is easily constructed from the information on a topographic map as shown in the example below.

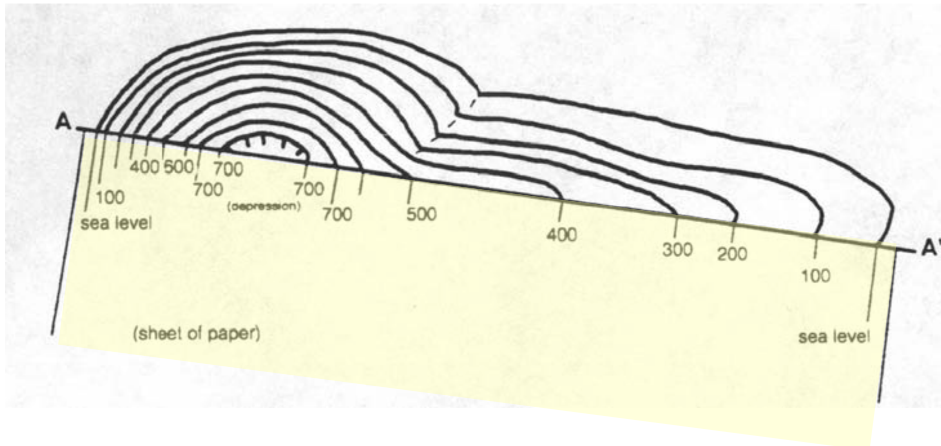
1. Select a line of profile (do not draw the line on the maps in the lab) (A-A' in Figure 6).

Figure 6



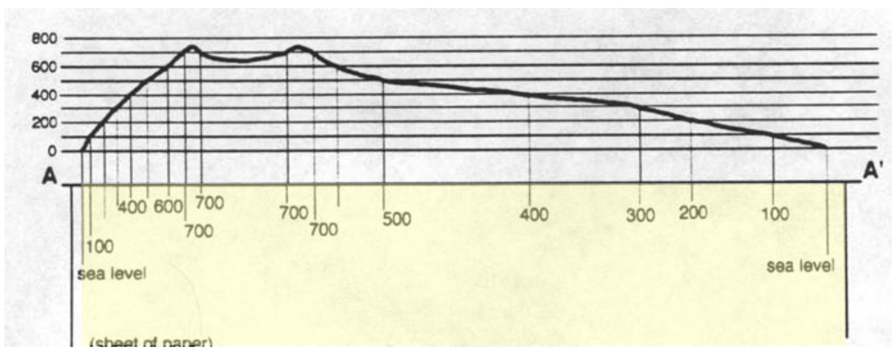
2. Place the edge of a piece of paper along the line. Mark the positions of the ends of the line. Without allowing the paper to move, mark the position of the contour lines where they meet the paper and note the elevation of the lines (Figure 7).

Figure 7



3. Place the paper below a set of ruled lines marked with the appropriate elevations (Figure 8). Then for each mark on the paper, project up to the elevation of the contour line represented by the mark and draw a point (generally one contour up or down for each point in order). Last, draw a line connecting the points to produce the profile.

Figure 8



Note that this is just an example. When you make a profile you must adjust the technique for the scale and contour interval of the map you are working with.

<u>Lab Procedure</u>

<u>DO NOT mark on the maps provided in lab!</u>

Carefully read and understand the material in the introduction of this lab exercise then answer all the questions below. Examine the text on the maps for important information. Consult the "Topographic Map Symbols" pamphlets that are available in the lab.

Questions/Exercises

Read the introduction to this lab to answer the following questions.

1. If something has "low relief", what does this mean? **(2 pts)**

   ____

2. Can something with "low relief" be at high elevation? (circle) **Y** or **N** Why? **(3 pts)**

   ____

   ____

3. Name someplace or something in southern California with high elevation. **(2 pt)**

   ____

4. Why must magnetic north be measured every year? Must geographic north be measured annually as well? **(3 pts)**

   ____

   ____

5. Other than oceans, what features are typically shown in blue patterns? **(2 pts)**

   ____

6. How could you tell a glacier apart from a lake on a topographic map? **(2 pts)**

   ____

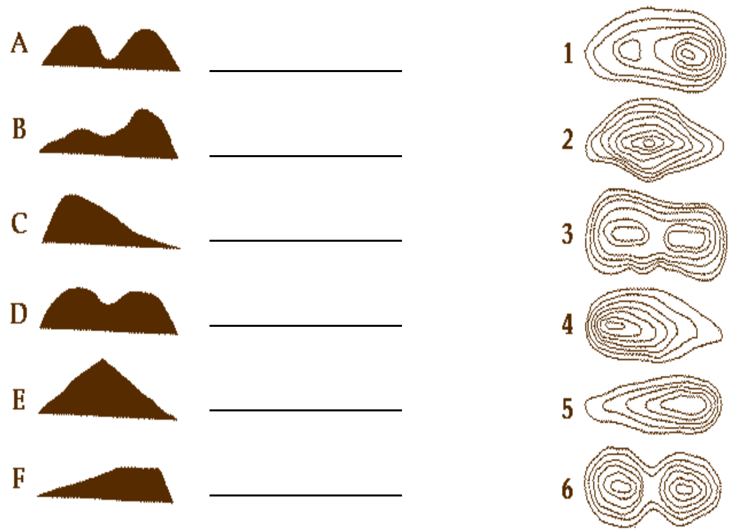
   ____

7. Why can't contour lines cross, merge or split? **(2 pts)**

   ____

   ____

8. Match each profile on the left with the matching contour lines on the right. Writing the appropriate number in the space. **(1 pt each)**



MAP PROJECTIONS:

9. Using a wall map or a globe determine the latitude and longitude of Pasadena, Ca. to the nearest degree. (Don't forget to include the hemisphere.) **(4 pts)**

   Latitude: ______________________ Longitude: ___________________________

10. Using a **flat world map,** stretch a string from *Caracas, Venezuela* to *Tokyo, Japan* along the <u>shortest</u> path between those points. What is the land nearest to the halfway point? **(2 pts)**

   ____

11. Now, do the same thing using a **globe**. What is the land nearest to the halfway point? **(2 pts)**

   ____

12. Explain why the paths are different. ("One's flat and one's round" is NOT an answer.) **(4 pts)**

   ____

   ____

13. Which is more accurate? _______________________ **(2 pts)**

   Why? ____

Use the **Pasadena, CA 7.5' Quadrangle map** to answer the following questions.

14. What is the longitude of the northwest corner of the map? **(2 pts)** ___________________

15. What is the longitude of the southwest corner of the map? **(2 pts)** ___________________

16. The western boundary of the map is therefore a line of longitude.

    Is it east or west longitude? **(1 pt)** __________________________

17. What is the latitude of the northeast corner? **(2 pts)** _________________

18. What is the latitude of the northwest corner? **(2 pts)** _________________

19. What is the latitude and longitude of the intersection of Fair Oaks Ave. and California Blvd. to the nearest 30" of arc? **(3 pts)**

    ____

20. What is the contour interval used on this map (include units!)? **(1 pts)**

    ____

21. What is the elevation of the intersection of Colorado Blvd. and Lake Ave.? **(3 pts)**

    ____

22. What is the elevation on Lake Ave. two miles north of this intersection? **(3 pts)**

    ____

23. What is the slope of Lake Ave. in feet/mile between the locations in the questions above? Hint: Divide the difference in elevation between the two points by the distance between them) **(4 pts)**

    ____

24. What is the elevation of the intersection of Lake Ave. & New York Dr.? **(3 pts)**

    ____

25. What is the elevation on Lake Ave. 3/4 mile north of this intersection? **(3 pts)**

    ____

26. What is the slope of Lake Ave. in feet/mile between these two locations? **(4 pts)**

____

27. What observation about the contour lines on the map supports the difference in the two slopes you calculated above? **(2 pts)**

____

28. Locate the **upper** Arroyo Seco and find the *gaging station* where the 1400' contour line crosses the stream. Notice that the contour line makes a distinct "V" with the tip of the V pointing upstream. How would a hike from the gaging station to the nearest paved road compare with a hike from the station to JPL? **(2 pts)**

____

____

29. Locate several debris basins on this map. Why are they located where they are? (What is their purpose?) **(3 pts)** ____

____

Use the **Idyllwild, CA 7.5' Quadrangle** map to answer the following questions.

30. Is Lake Hemet a natural or man-made lake? **(3 pt)**______________________

How can you tell? __________________________________

31. Which stream contributes the most water to the lake? **(4 pt)** ______________________

How can you tell? ____

____

32. How much would the water in Lake Hemet have to rise in order to flood the landing strip in Garner Valley? **(2 pts)**_______________________

Use the **Mammoth Mtn., CA 7.5' Quadrangle map** to answer the following questions.

33. What is the contour interval on this map? **(1 pt)**__________________________

34. Locate Inyo Crater Lakes near the east edge of the map. What do the “teeth” on contour lines around the lakes mean? **(2 pts)**______________________________

35. What is the maximum elevation of the water surface of the southern Inyo Crater Lake? **(2 pts)**____________ Is this elevation in meters or feet?_____________

36. What are the two brown areas in the northeastern part of the map? **(2 pts)**

____

37. In the space below, construct a **topographic profile** (see introduction pg. 6) along the route the gondola takes from the Mammoth Mtn. Main Lodge to the top of Mammoth Mountain. Follow the bend in the route. Treat each horizontal line on the graph below as one contour interval. Be sure to label the elevations on the profile. **(6 pts)**

38. What is the approximate *vertical exaggeration* in the profile above? (That is, what is the ratio between some distance on the vertical axis compared to the same distance on the horizontal axis? For example, if a mountain appears twice a high as it really is the ratio is 2:1) **(2 pts)**

____

39. Locate the boundary line between Mono and Madera Counties. Do any streams flow across this boundary? Why? **(2 pts)**____

____