These slides cover topics that we will likely not have time for in class.

Converting Lat/Lon to UTM

$$UTM\ North = k_o\left\{A' \cdot K1 \cdot \phi - B1 \cdot \sin 2\phi + \frac{[.36(\lambda_o - \lambda)]^2 \cdot a \cdot \sin\phi \cdot \cos\phi \cdot K2}{\sqrt{1 - e^2 \sin^2\phi}}\right\}$$

$$UTM\ East = 500{,}000 \pm \left\{.36(\lambda_o - \lambda) \cdot K3 \cdot \cos\phi + [.36(\lambda - \lambda_o)]^3 \cdot K4 \cdot \cos^3\phi(1 - \tan^2\phi + e'^2\cos^2\phi)\right\} / \sqrt{1 - e^2 \sin^2\phi}$$

Converting UTM to Lat/Lon

$$N = k_o(A' \cdot K1 \cdot \phi' - B' \sin 2\phi' + 17.209 \sin 4\phi')$$

$$\phi = \phi' - \left(q^2\left[\frac{\tan\phi'(1 + e'^2\cos\phi) \cdot (1 - e^2\sin^2\phi') \cdot 10^{12}}{2 \cdot a^2 \cdot k_o^2 \cdot \sin 1''}\right] + q^4\left\{\frac{\tan\phi'(1 - e^2\sin^2\phi)^2 \cdot 10^{24}}{24 \cdot a^4 \cdot k_o^4 \cdot \sin 1''} \times (5 + 3 \cdot \tan^2\phi' + 6 \cdot e'^2\cos^2\phi' - 6e'^2\sin^2\phi' - 3e'^4\cos^4\phi' - 9e'^4\cos^2\phi'\sin^2\phi')\right\}\right) / 3600$$

$$\lambda = \lambda_o \pm q\frac{\sec\phi'\sqrt{1 - e^2 \cdot \sin^2\phi} \cdot 10^6}{a \cdot k_o \cdot \sin 1'' \cdot 3600} - q^3\frac{\sec\phi'(1 - e^2\sin^2\phi)^{1.5} \cdot (1 + 2\tan^2\phi' + e'^2\cos^2\phi') \cdot 10^{18}}{6 \cdot a^3 \cdot k_o^3 \cdot \sin 1'' \cdot 3600}$$

Converting between Lat/Lon and UTM

- Save a waypoint in the position format you have the coordinate in.
- Switch to the position format you want to convert to.
- Recall the waypoint

More about UTM

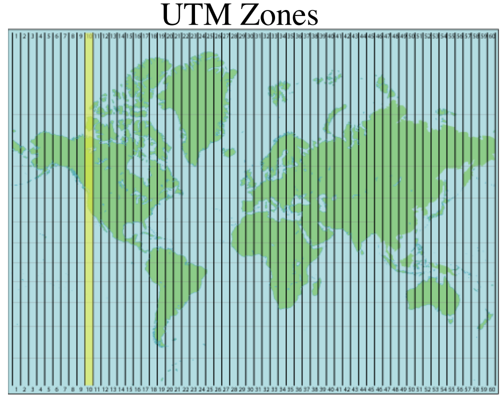
Transverse Mercator Projection

- Central meridian is selected by the map maker and touches the cylinder.
- Maps using the projection can show the whole Earth, but directions, distances, and areas are reasonably accurate only within 15° of the central meridian.

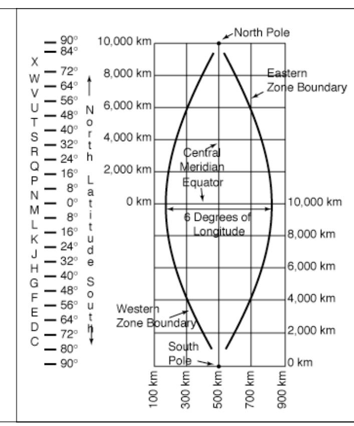
UTM Zones

- World is divided into 60 zones.
- Each zone is 6° of longitude wide.
- Zones are numbered 1 to 60, starting at 180° and progressing to the east.

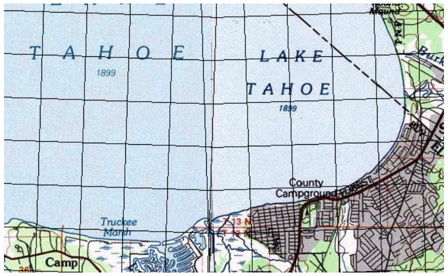
UTM Zones



UTM Zone Details



Boundary between UTM zones



Maps represent large areas on the ground on small sheets of paper.

A map's **scale** describes the ratio of map distance to ground distance.

A **ratio** is not tied to any specific unit of measure

You must use the same units on both sides of the ratio.

For a map scale of 1:24,000

- 1 inch on the map ⇔
  24,000 inches on the ground
- 1 mm on the map ⇔
  24,000 mm on the ground
- 1 standard dog paw on the map ⇔
  24,000 sdp's on the ground

Measuring 24,000 inches is a problem when the tape measure is marked in feet.

- We can convert one side of the ratio to an equivalent measure, in larger units, and still preserve the ratio.
- We know that there are 12 inches in 1 foot
  Thus 24,000 inches / 12 = 2,000 feet
- So on a 1:24,000 scale map,
  1 inch ⇔ 2,000 feet

Some maps do not list their scale ratio

- Instead they give us a distance equivalence

  1 inch ⇔ 1 mile

- We can determine the scale ratio by converting the units to be the same on each side of the equivalence.

1 inch ⇔ 1 mile

- 1 mile = 5,280 feet
  Thus we can say the equivalence of
  1 inch ⇔ 5,280 feet is also true for this map.
- 1 foot = 12 inches
  So 1 inch ⇔ 5,280 X 12 inches
  or 1 inch ⇔ 63,360 inches
- Thus the scale ratio is 1:63,360

Scale Ratio is also a Fraction

- A map scale of 1:24,000 can also be used as the fraction

$$\frac{1}{24{,}000}$$

or if you do the division 0.0000416

Metric units make scale calculations easy

- Converting between larger and smaller units is all done with multiples of 10.
- Metric measuring devices are subdivided in multiples of ten. No fractional parts of an inch to deal with (i.e. 1/2, 1/4, 1/8, 1/16)

Metric Prefixes

Prefix	Symbol	Multiplier
mega	M	1,000,000
kilo	**k**	**1,000**
hecto	h	100
deka	da	10
deci	d	0.1 or 1/10th
centi	**c**	**0.01 or 1/100th**
milli	**m**	**0.001 or 1/1000th**
micro	μ	0.000001 or 1/1,000,000th

Relative Scale

- A 1:24,000 scale map is a *larger* scale than a 1:100,000 scale map
- A kilometer is larger on the 1:24,000 map than it is on a 1:100,000 map
- 1/24,000 = 0.0000416 is larger than 1/100,000 = 0.00001

Simple Map Scale Questions

- On a 1:10 scale map

  1 inch (map) ⇔ ? inches (ground)

  420 millimeters (map) ⇔ ? millimeters (ground)

  3.4 feet (map) ⇔ ? feet (ground)

  So far our measurement units have been the same on both sides of the equation….

More Map Scale Problems

- On a 1:1000 scale map

  42 millimeters on the map ⇔ **?** millimeters on the ground

  1 mm on the map ⇔ **?** meters on the ground

  3.4 inches on the map ⇔ **?** feet on the ground

  500 m on the ground ⇔ **?** millimeters on the map

  2000 feet on the ground ⇔ **?** inches on the map

More Map Scale Problems

- On a 1:24,000 scale map

  42 millimeters on the map ⇔ **?** millimeters on the ground

  10 mm on the map ⇔ **?** meters on the ground

  3.5 inches on the map ⇔ **?** feet on the ground

  500 m on the ground ⇔ **?** millimeters on the map

  2000 feet on the ground ⇔ **?** inches on the map

Some maps show only a scale bar

- You can measure the length of the scale bar and do the scale calculation to determine the scale of the map.

The 1km scale bar is 56mm long. What scale is the map?

56mm ⇔ 1km

0.056m ⇔ 1000m (convert to similar units)

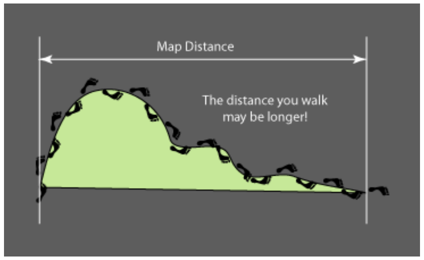
0.056m ⇔ 1000m (divide to get a one on the left side)
0.056 0.056

1m ⇔ 17857m

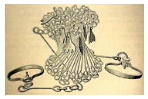
The map scale is 1:17,857

Measuring Distance in the Field

Map Distance v.s. Terrain Distance



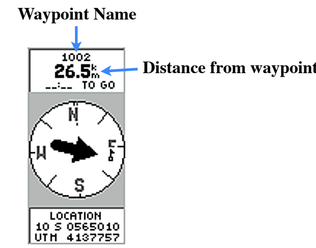
Using a tape or "chain"



Other methods

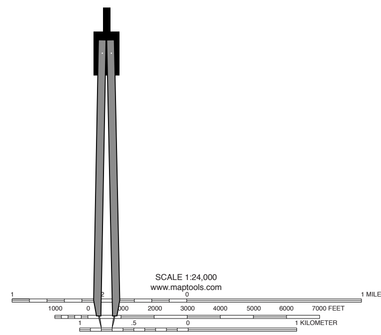
- Roller wheel
- Car or bike odometer
- Optical range finder
- Laser range finder

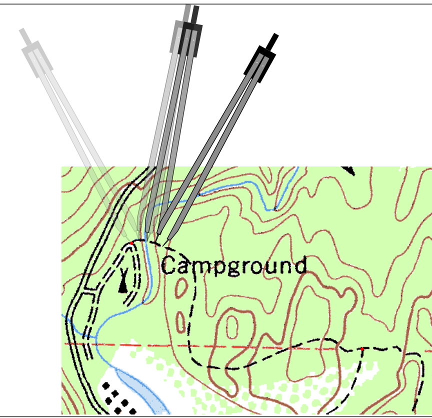
GPS Distance Measurement



Measuring Distance on a Map

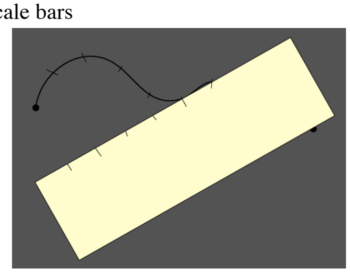
- Transfer the distance to the scale bars to get ground distance.
- Measure in millimeters or inches and convert to ground units using the map scale.
- Use a map measuring tool set for the map's scale.





Paper Edge Technique

- Use for straight line or curvy path
- Transfer to the scale bars or measure and do the math.



String or Wire

- Position a piece of string or thin wire along the path your are trying to measure.
- Straighten it out and use the scale bars or measure it and do the math.
- You can use the lanyard on your compass!

Map Measuring Gadgets

Distance and Time

- Time is usually what we think about
- $\text{Time}_{(\text{minutes})} = (60/\text{Speed}_{(\text{km per hour})}) \times \text{Distance}_{(\text{km})}$

Some guides to remember

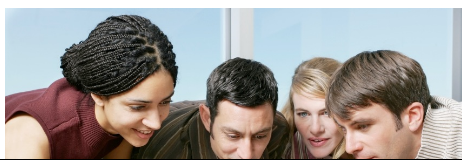
- In the parking lot, it took about 1 minute to travel 100m.
  - That's 10 minutes for a kilometer or 6 km/hr
  - Flat, Paved, Sea Level, No Pack, Not Tired
- Most hiking parties travel at 3-5 km/hr
- When ascending add a minute for each 20-40 ft. in elevation gained to the horizontal travel time.
  - Add 2 minutes for each 40 ft contour line climbed.
  - Add 1 minute for each 20 ft contour line climbed.
  - Really slow? Add 4 mins. per 40 ft. and 2 mins. per 20 ft.

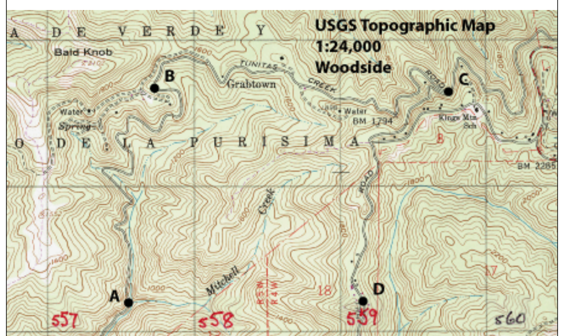
Measure in Current Conditions

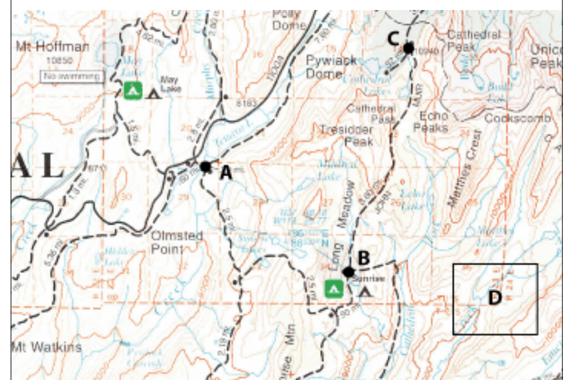
- Use 15-20 minutes/km plus 2min per 40 ft. elevation gain, until you have better measurements.
- Make your own horizontal and vertical speed measurements in the terrain you are in.
  - Time a kilometer on the flats and on a slope
  - Use your GPS to get your speed in km/hr and your altitude change over a period of time.
- Use the 1km grid lines and the contour lines when making time estimates.

In class exercise on scale & distance

- See the handout







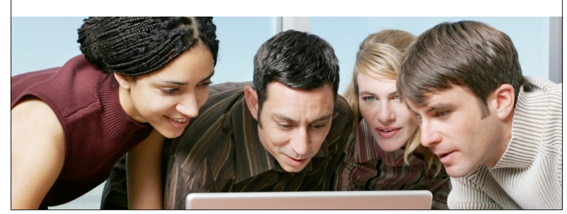
Adding a UTM Grid

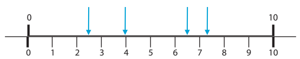
- Many maps still do not have good geographic coordinate grid references.
- To use them with a GPS, you need to add the coordinate grid.

If there are no coordinates…

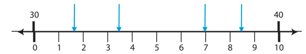
- We can convert known lat/lon points to UTM.
- We can find features on a different map and match them to our map.
- We can measure coordinates using our GPS receiver at known points.

Number Line Exercise

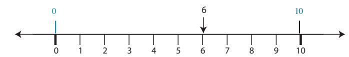




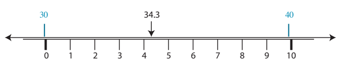
Locate and label the following points on the number line above:
4, 6.5, 7.25, and 2.368



Locate and label the following points on the number line above:
37, 33.5, 31.75, and 38.465



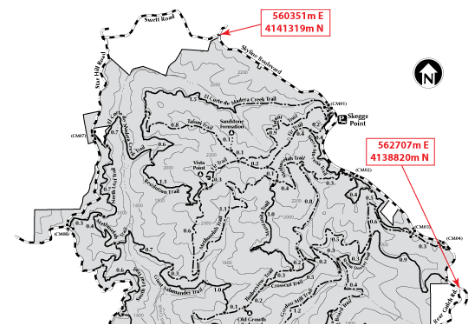
Locate and label 0 and 10 on the section of number line above.



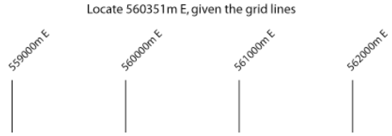
Locate and label 30 and 40 on the section of number line above.

Let's try it with a MidPen Open Space Map

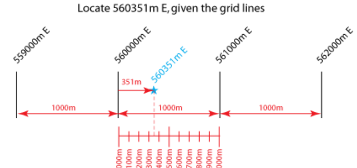
- Coordinates for two locations have been identified using the USGS 1:24,000 scale map of the area. We could also have gone to the locations and measured coordinates with our GPS.



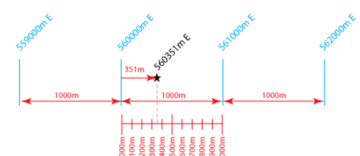
Locate 560351m E, given the grid lines

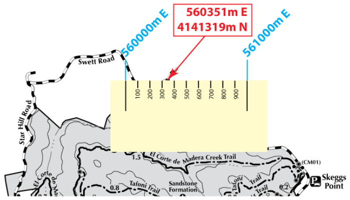


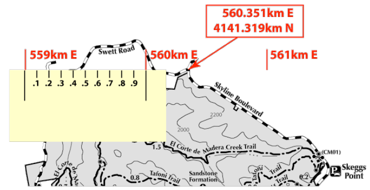
Locate 560351m E, given the grid lines

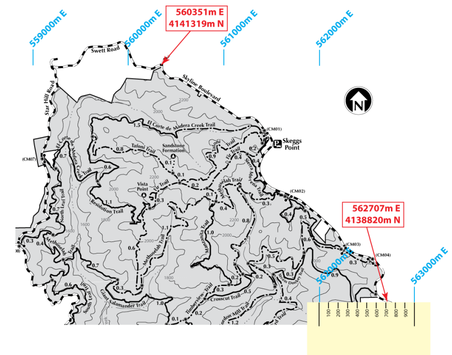


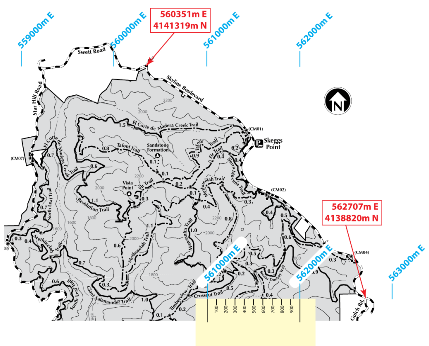
Now let's do the opposite problem...
Locate the grid lines for 560000m E and 561000m E,
given the location of the point 560351m E

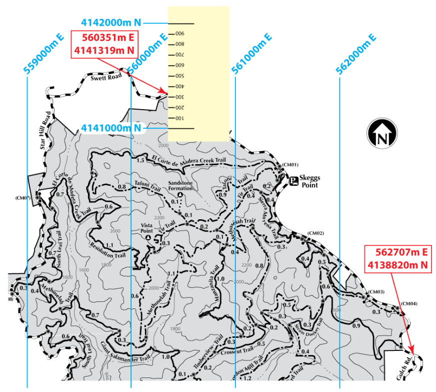


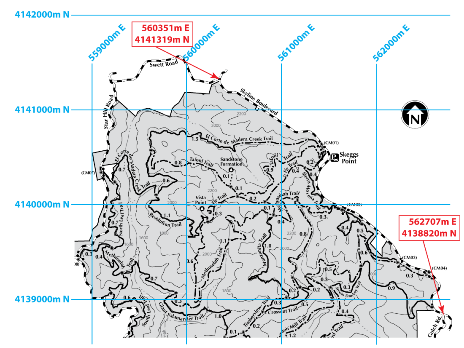






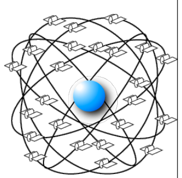






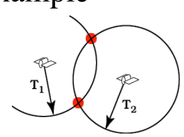
How the GPS System Works

- 24 satellites + spares
- 6 orbital planes 55° inclination
- Each satellite orbits twice every 24 hours.
- At least 4 satellites visible any time of day, anywhere in the world.



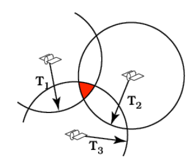
A 2 Dimensional Example

- Time for the signal to reach GPS receiver is determined.
- Distance is computed by multiplying by the speed of light.
- Distance from two satellites defines 2 points (in 2 dimensional space.)



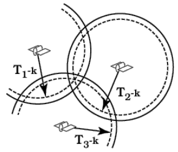
A 2 Dimensional Example

- The distance from a third satellite narrows the location to an "error triangle."



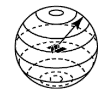
A 2 Dimensional Example

- Assume the error in each of our measurements is a constant, k.
- Solve for k, so that the "error triangle" is as small as possible.



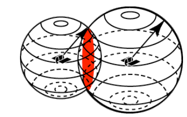
Now for 3 Dimensions

- Distance from a single satellite locates a position somewhere on a sphere.



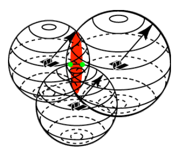
Now for 3 Dimensions

- Two measurements put the location somewhere on a circle at the intersection of the two spheres.



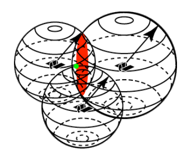
Now for 3 Dimensions

- Three measurements put the location at one of two points at the intersection of the three spheres.



Now for 3 Dimensions

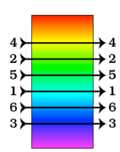
- A fourth measurement selects one of the two points, and provides enough information to solve for the constant error.



Determining Distance to the GPS Satellites

Spread Spectrum Radio

- Imagine that a radio transmitter can transmit on 6 channels.
- Every second the channel is changed according to a predetermined sequence.



Spread Spectrum Radio

- To receive the signal, the receiver must listen to the same sequence of channels.
- The transmitter and receiver must also be synchronized.
- The closer the receiver is to being synchronized, the more of the "conversation" will be heard.

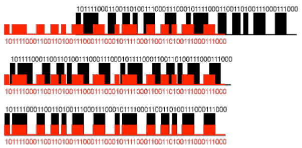
The Coarse Acquisition Code

A short segment of PRN Code

- Each satellite uses a unique Pseudo Random Noise (PRN) code for spread spectrum modulation.
- The C/A code is 1024 bits in length, and is sent at a 1 MHz rate. Thus the code repeats every millisecond.
- The noise like code modulates the L1 carrier signal at 1575.42 MHz. The signal is spread over a 1 MHz bandwidth.

The Coarse Acquisition Code

- Your GPS syncs with each satellite by shifting the timing of the start of an internally generated PRN code.



Time Difference is Distance

- Timing of the signals transmitted by the satellites is very accurate due to the dual atomic clocks on board each satellite.
- The time difference between the two PRN codes represents the time it took the radio signal to travel from the satellite to the GPS receiver.
- The distance or "range" to the satellite is given by the equation
  range = time difference X speed of light

Time Difference is Distance

- The clock signal your GPS uses to generate the PRN code is very inaccurate compared to the atomic clocks onboard the satellites.
- However this clock error is constant for each of the measurements to the different satellites being tracked.
- The clock error can be computed when measurements are available from four or more satellites.

Satellite Position is Known

- The position of each satellite is known with great accuracy. Current orbital position data is transmitted by each satellite.
- Orbits are monitored by ground control stations. Corrected orbital information is uploaded several times a day.
- Given the position of each satellite and the distance from the GPS receiver to each satellite, the position of the GPS receiver can be computed.

GPS Limitations – It's an electronic gadget…

- Failure could result from…
  - Low battery
  - Too cold
  - Got wet
  - Got dropped
  - Forgot how to use it!
- Don't rely on your GPS as your only means of navigation!

GPS Limitations – Fewer than 4 satellites visible

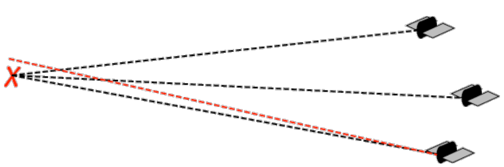
- Your GPS needs to be able to receive a strong signal from at least 4 satellites to report an accurate position
- Problems could be caused by…
  - The sky is obscured by canyon walls, mountains, or tall buildings.
  - Dense tree canopy. Especially if it's wet.
  - Antenna is shielded by metal from a car, aircraft or building.
  - Low batteries may reduce receiver sensitivity.

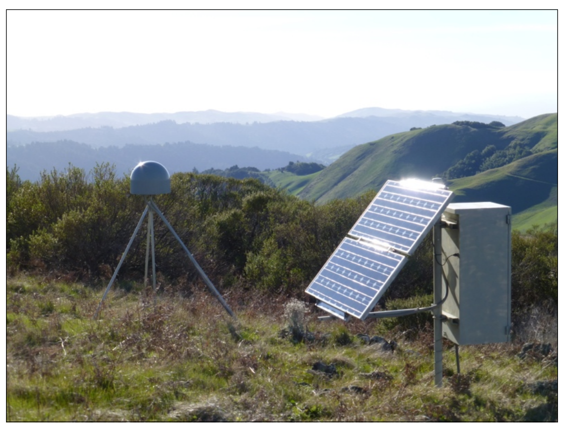
GPS Limitations – Poor satellite geometry

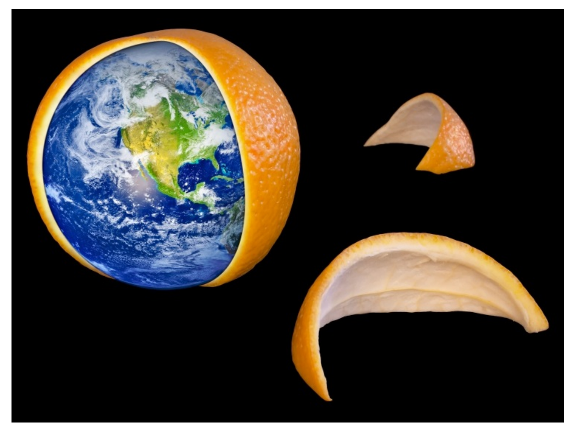
A small cluster of satellites can result in a large position error.

Similar to triangulating with mountain peaks that are close to one another.

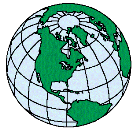
Check your EPE!



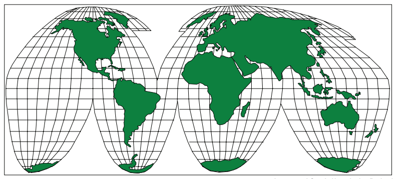




The “Orange Peel” Problem



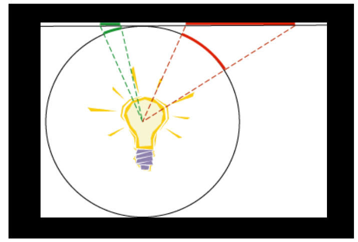
- The earth is round. The maps are flat.
- How do we go from round to flat with out getting a jagged mess?



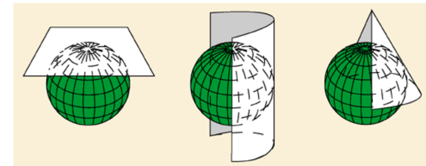
Interrupted Goode Homolosine Projection

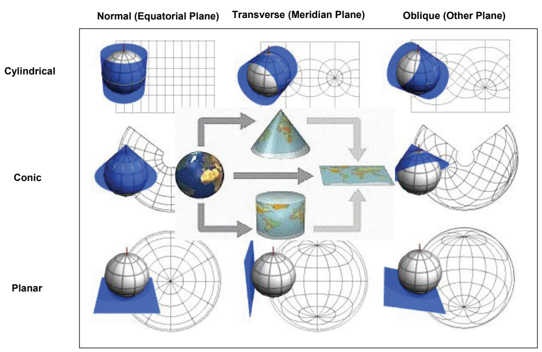
Map Projections

- A 2 dimensional example



Basic Projection Types

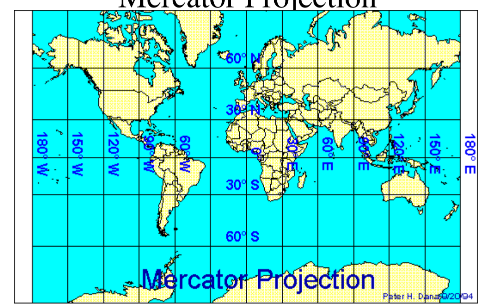




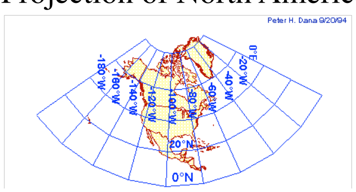
Distortion

- The further from the line(s) where the map touches the globe, the more distortion is introduced.

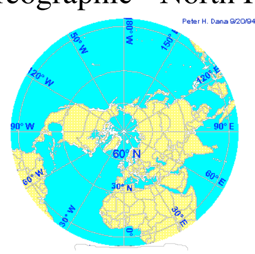
Mercator Projection

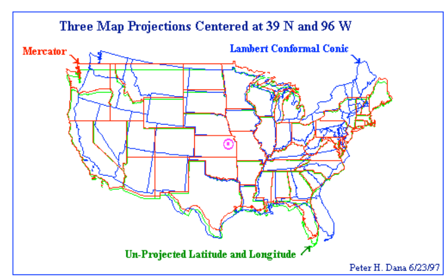


Lambert Conformal Conic Projection of North America



Stereographic - North Pole





Do we care?

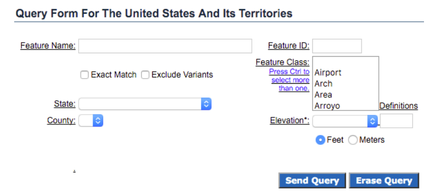
- The less area covered by the map or the larger the map scale. The less impact the map's projection has.
- For wilderness navigation we can ignore the map projection on most of the maps we use.

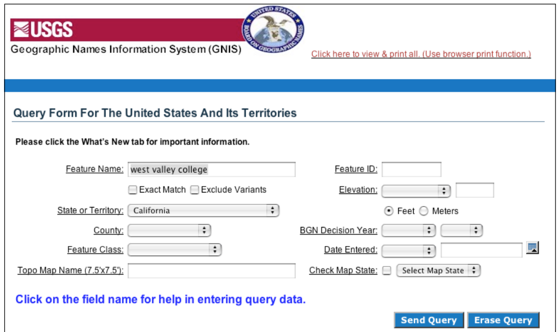
Which Map?

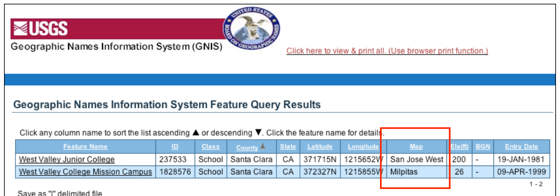
- Use the Geographic Names Information System (GNIS)
- Paper Index Maps

Geographic Names Information System

geonames.usgs.gov







USGS
Geographic Names Information System (GNIS)
Click here to view & print all. (Use browser print function.)

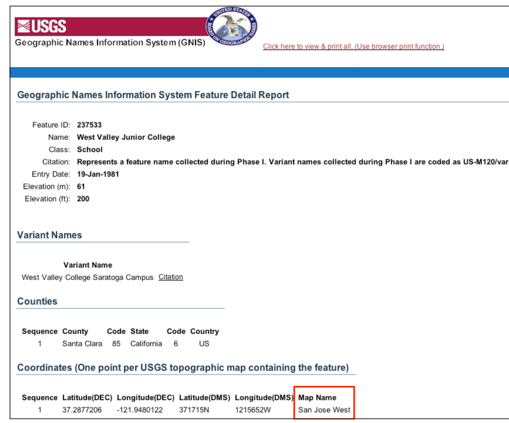
Geographic Names Information System Feature Query Results

Click any column name to sort the list ascending ▲ or descending ▼. Click the feature name for details.

Feature Name	ID	Class	County	State	Latitude	Longitude	Map	Ele(ft)	BGN	Entry Date
West Valley Junior College	237533	School	Santa Clara	CA	371715N	1215652W	San Jose West	200	-	19-JAN-1981
West Valley College Mission Campus	1828576	School	Santa Clara	CA	372327N	1215855W	Milpitas	26	-	09-APR-1999

1 - 2

Save as "|" delimited file



USGS
Geographic Names Information System (GNIS)
Click here to view & print all. (Use browser print function.)

Geographic Names Information System Feature Detail Report

Feature ID: **237533**
Name: **West Valley Junior College**
Class: **School**
Citation: **Represents a feature name collected during Phase I. Variant names collected during Phase I are coded as US-M120/var.**
Entry Date: **19-Jan-1981**
Elevation (m): **61**
Elevation (ft): **200**

Variant Names

Variant Name	
West Valley College Saratoga Campus	Citation

Counties

Sequence	County	Code	State	Code	Country
1	Santa Clara	85	California	6	US

Coordinates (One point per USGS topographic map containing the feature)

Sequence	Latitude(DEC)	Longitude(DEC)	Latitude(DMS)	Longitude(DMS)	Map Name
1	37.2877206	-121.9480122	371715N	1215652W	San Jose West

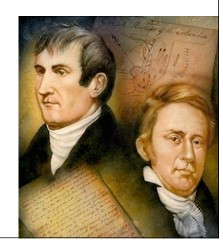
Topo map sources

- USGS
  – Menlo Park Office usgs.gov
- Outdoor Retailers
- www.usgsquads.com
- myTopo.com
- topozone.com
- terraserver.com

Public Land Survey System

"Your observations are to be taken with great pains and accuracy, to be entered distinctly and intelligibly for others as well as yourself to comprehend all the elements necessary, with the aid of the usual tables, to fix the latitude and longitude of the places at which they were taken"

– Letter from President Thomas Jefferson to Meriwether Lewis June 20, 1803



Why The Need For The PLSS

- Replace older land description system
- Cover vast amounts of land
- Enable westward migration
- Uniform method to describe and convey land titles
- Easy for a lay person to locate a parcel of land

Land Ordinance Act

- Land Ordinance Act on May 20, 1785, by the Continental Congress
  - Be it ordained by the United States in Congress assembled, that the territory ceded by individual states to the United States, which had been purchased of the Indians inhabitants, shall be disposed of in the following manner: A surveyor from each state shall be appointed by congress or a committee of the states, who shall take an oath for the faithful discharge of his duty, before the Geographer of the United States, who is hereby empowered and directed to administer the same; and the surveyor under whom he acts.
  - First Geographer of the United States "Thomas Hutchins"

Beginning Point of the U.S. Public Land Survey

The Survey began in 1785.

In the Field

- Contracts for survey work were awarded to deputy surveyors by competitive bid.
- The deputy surveyor, with a crew of chainmen, axemen, and a compassman, ran the survey lines in the field and was responsible for erecting survey monuments, marking "bearing trees," and recording all measurements in his field notes.
- The deputy surveyor's work was verified by the surveyor general, and the field notes and plats submitted to the commissioner of the GLO for approval.

Base Line

- Base line is extended east and west on a true parallel of latitude
  - Monuments are placed at intervals of 40 chains (1/2 mile)

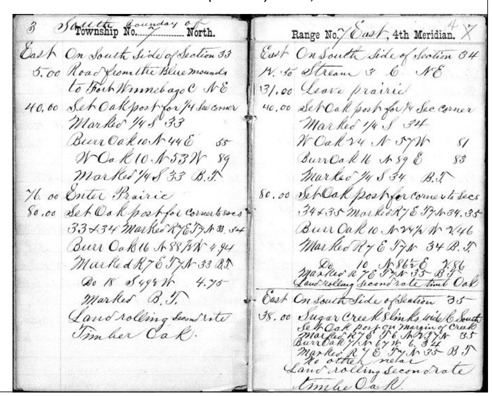
Principal Meridian

- True meridian that is astronomically determined and is extended from the initial point, north and south.
  - Monuments are placed at intervals of 40 chains (1/2 mile)

Field Notes (Oct. 1832) **Mullett, John H.**

Section Line

Wisconsin Township
7 North
Range
7 East
Section 33
S. Boundary


3 South boundary of Township No. 7 North. Range No. 7 East, 4th Meridian.

East On South Side of Section 33
5.00 Road from the Blue mounds to Fort Winnebago C NE
40.00 Set Oak post for 1/4 Sec corner Marked 1/4 S 33
Burr Oak 10 N 44 E 55
W Oak 10 N 53 W 89
Marked 1/4 S 33 B.T.
76.00 Enter Prairie
80.00 Set Oak post for corner to secs 33 & 34 Marked R7E T7N 33. 34
Burr Oak 16 N 88 1/2 W 4.94
Marked R7E T7N 33 B.T.
Do 18 S 49 1/2 W 4.75
Marked B.T.
Land rolling second rate Timber Oak.

East On South Side of Section 34
14.50 Stream 3 C NE
31.00 Leave prairie
40.00 Set Oak post for 1/4 Sec corner Marked 1/4 S 34
W Oak 24 N 57 W 81
Burr Oak 16 N 89 E 83
Marked 1/4 S 34 B.T.
80.00 Set Oak post for corner to secs 34 & 35 Marked R7E T7N 34. 35
Burr Oak 10 N 24 1/2 W 2.46
Marked R7E T7N 34 B.T.
Do 10 N 86 1/2 E 2.86
Marked R7E T7N 35 B.T.
Land rolling second rate timb Oak

East On South Side of Section 35
38.00 Sugar Creek 8 links wide C South
Set Oak post on margin of Creek Marked R7E T6N T7N 35
Burr Oak 7 N 67 W 6.34
Marked R7E T7N 35 B.T.
No other near
Land rolling second rate Timber Oak.

Public Land States

- Alabama
- Alaska
- Arizona
- Arkansas
- California
- Colorado
- Florida
- Idaho
- Illinois
- Indiana
- Iowa
- Kansas
- Louisiana
- Michigan
- Minnesota
- Mississippi
- Missouri
- Montana
- Nebraska
- Nevada
- New Mexico
- North Dakota
- Oklahoma
- Ohio
- Oregon
- South Dakota
- Utah
- Washington
- Wisconsin
- Wyoming

Congressional Acts

- 1812
  - Created the General Land Office
- 1849
  - Congress established the Department of the Interior
- 1946
  - Abolished the General Land Office and Created the Bureau Of Land Management

Land Grants and Ranchos

- As part of the settlement of the Mexican War of 1846-1848, "ranchos," or private land holdings established during Spanish and Mexican rule, were honored by the U.S. Government under the Treaty of Guadalupe Hidalgo with Mexico.
- These ranchos, which were primarily along coastal areas of present-day California and in the San Joaquin and Sacramento Valleys, covered 9 million acres, or 14,000 square miles.

Land Grants and Ranchos

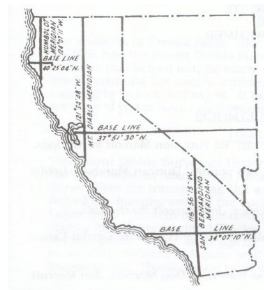
- To delineate these private lands, the United States Deputy Surveyors were assigned to survey the rancho boundaries.
- During the 1850s more than 30 government survey parties were deployed.

Initial Point

- Surveying the public lands in California was no easy task.
- Because of the size of the state and the steepness of terrain in many areas of California, the Surveyor General of the United States decided that three initial points were needed.

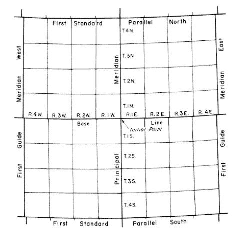
Initial Points for California & Nevada

- Mt. Diablo
  - Contra Costa County
  - 1851
- San Bernardino Mountain
  - San Bernardino County
  - 1852
- Mt. Pierce
  - Humboldt County
  - 1853.



Township and Ranges

- 6 miles square

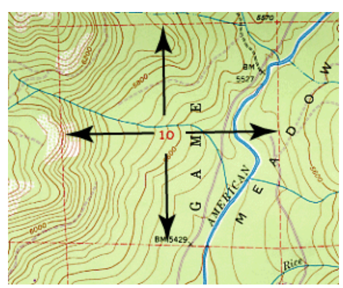


Sections

- 1 mile square
- 640 acres

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

Section 10



School Section

- Sections 16 and 36 of every township were usually deeded to the State.
- Section 16, the *school section*, was leased to generate funds to support public schools.
- Section 36 was leased to fund state government operations.

Homestead Act of 1862

- Allowed anyone to file for a quarter-section of free land.
- The land was yours at the end of five years if…
  - you had built a house on it
  - dug a well
  - broken (plowed) 10 acres
  - fenced a specified amount
  - and actually lived there

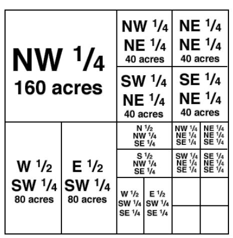
Homestead Act of 1862

- Additionally, one could claim a quarter-section of land by "timber culture"
  (commonly called a "tree claim").
  - This required that you plant and successfully cultivate 10 acres of timber.

Railroad Act of 1862

- As an incentive to get railroad track built, railroad companies were granted alternate odd numbered sections of land, to the amount of five alternate sections per mile, on either side of a completed rail line.

Section Subdivisions



Roads, Fences & Monuments

- In rural areas its is common for roads and fence lines to follow section or quarter section boundaries.
- It is common to find physical "monuments" marking section and quarter section corners.

Using Lat/Lon is Tricky

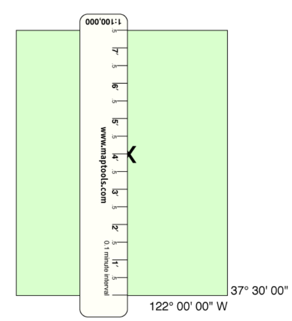
- Take a look at the "Lat/Lon Practice Map" handout.
- Can you quickly determine what map feature is at:

  N 38° 36' 22" W 120° 03' 58"

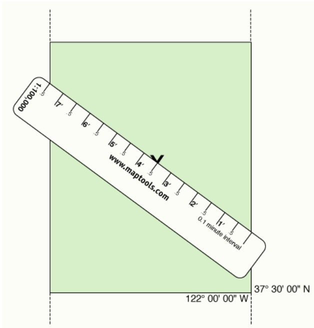
Plotting Lat/Lon Video

Reading Lat/Lon Video

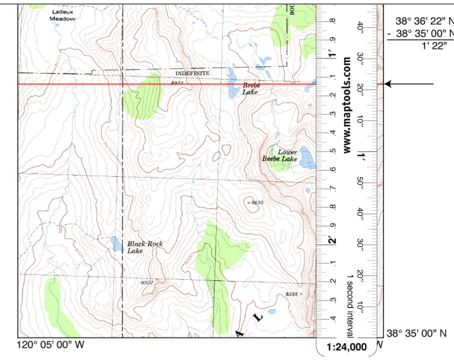
Measuring Latitude

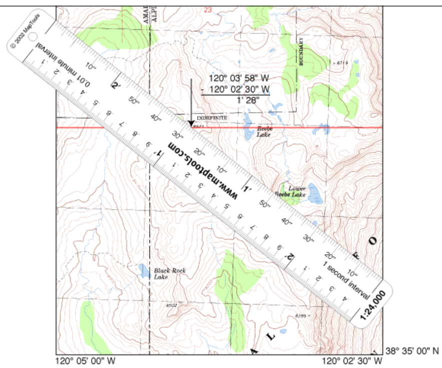


Measuring Longitude



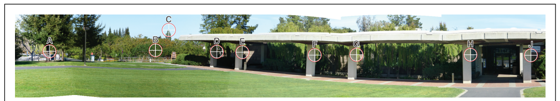
Lat/Lon Coordinate Exercise





Compass Bearing

Accuracy Challenge

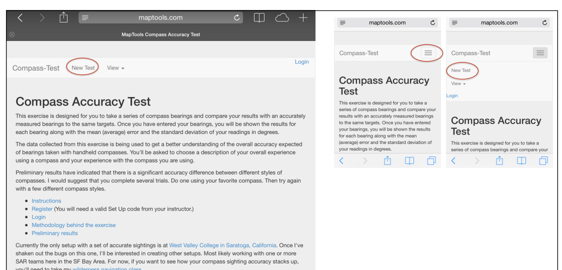


Align your sighting with the right edge of all targets, except **C**.

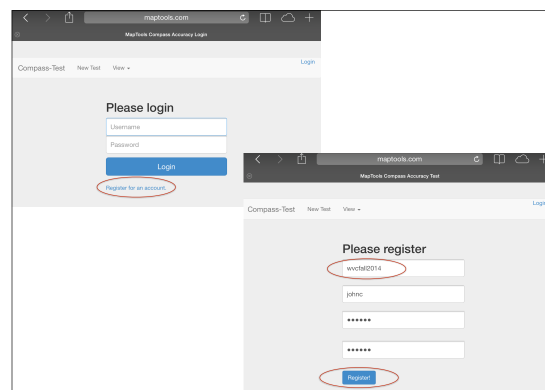
A - Top of tree **B** - Lamp post **C** - Top of distant tree **D** - Column **E** - Column **F** - Column

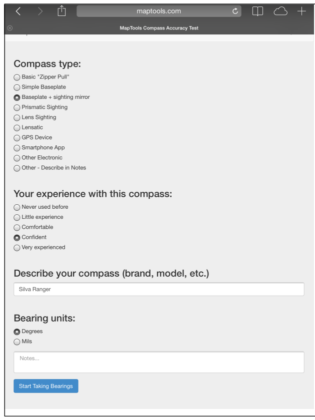
G - Column **H** - Column **J** - Column

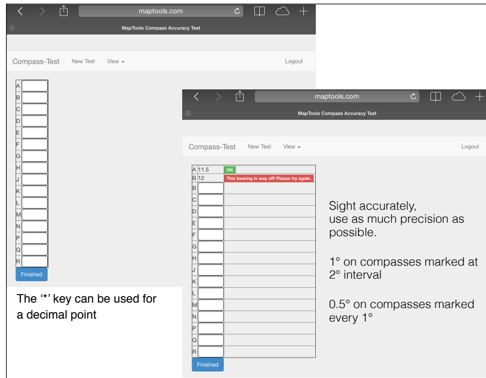
There are 18 targets to sight.



Online data collection & analysis
Point your browser to
maptools.com/compass-test
or use the QRCode on the handout.







The '*' key can be used for a decimal point

Sight accurately, use as much precision as possible.

1° on compasses marked at 2° interval

0.5° on compasses marked every 1°

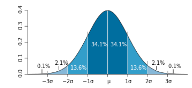
maptools.com

maptools.com/compass-test/test/view/37

WVC Lot 2 East End

Date: 11/03/2014
User: johncarnes
Compass: Silva 54

Bearing	Actual Bearing	Sighted Bearing	Difference
A	11.2	11.5	0.3
B	37.4	38.0	0.6
C	59.2	60.0	0.8
D	63.4	64.0	0.6
E	107.1	108.0	0.9
F	109.9	110.5	0.6
G	136.5	138.0	1.5
H	137.4	138.5	1.1
J	187.1	189.0	1.9
K	201.8	203.0	1.2
L	216.0	217.0	1.0
M	238.4	243.0	4.6
N	267.8	268.5	0.7
P	280.0	280.5	0.5
Q	306.7	307.0	0.3
R	329.6	330.0	0.4
		Mean	1.1
		Standard Deviation	1.4



Layout ID	Test ID	User	Compass	Mean	Standard Deviation
1	1	johncarnes	Brunton 54LU	0.1	0.5
4	15	johncarnes	54LU	0.0	0.8
4	12	johncarnes	Brunton Eclipse Mirrored	-1.0	1.3
1	4	johncarnes	Brunton Sightmaster	-0.1	1.7
1	9	johncarnes	Cammenga 3H	-0.5	1.8
1	3	johncarnes	Silva Ranger	-0.1	1.9
4	11	johncarnes	Francis Barker M-73	1.8	2.0
1	7	johncarnes	China Black Sighting	-0.6	2.3
4	14	johncarnes	Brunton Eclipse GPS	-0.5	2.6
1	8	johncarnes	Francis Barker M-73	1.8	2.9
4	13	johncarnes	Celestron w/ Glasses	-3.3	3.5
4	10	johncarnes	iPhone 4S Theodolite Pro app	1.1	5.2

How I measured accurate bearings

- Used differential GPS to find a 90°T base line (~210m)
- Used surveyors total station to transfer bearings from the baseline to two points outside of the classroom.
- Used total station to sight bearings to targets.
- Overall accuracy +/- 0.2° based on the baseline accuracy.
- Targets measured relative to the baseline +/- 0.01°.

Compass Test Sheet

Field Exercise

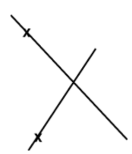
- Practice sighting bearings
- Return to classroom in 45 minutes.

Triangulation Example

Location by Intersecting Back Bearings or Resectioning (aka Triangulation.)

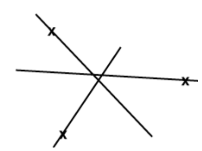
Location by Intersecting Back Bearings

- Two direction lines define a point.



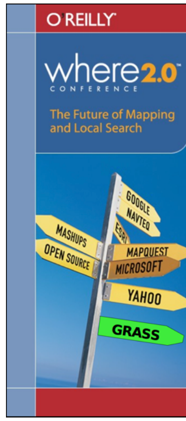
Location by Intersecting Back Bearings

- A third direction lines provides an error check.



Location by Intersecting Back Bearings

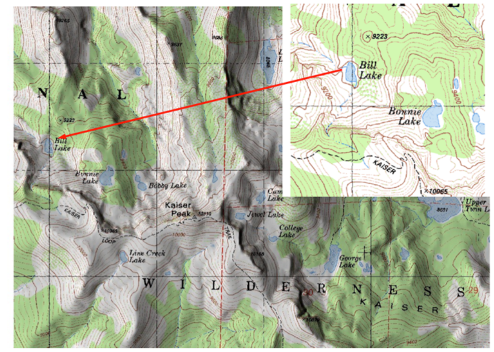
- Avoid picking 2 reference points that are close to each other. A small error in the angle will make a big difference in position. A 90° separation is best.



Wilderness Navigational Planning Using GRASS GIS Analysis and Public Geographic Data

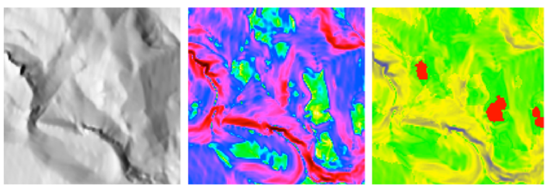
Dylan E. Beaudette
University of California at Davis
Dept. Land, Air, Water Resources

GRASS Basics: Planning a Wilderness Adventure



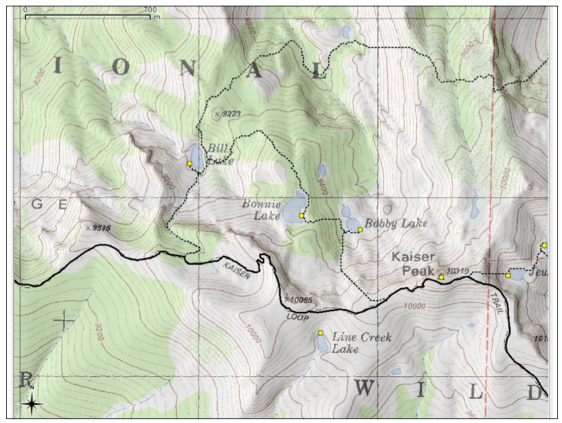
We would like to visit numerous alpine lakes located some distance from the main trail.

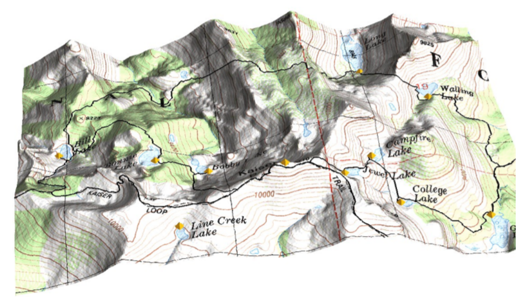
GRASS Basics: Generate Travel "Friction" Map



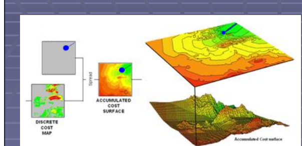

```
#update our slope map, to include traversing water features, and prefering wooded areas
#add a "cost" of 1000 to lake areas
r.mapcalc "new_slope = if(isnull(lakes) == 0, 1000.0+slope, slope)"

#subtract a small amount of cost for wodded areas:
r.mapcalc "new_slope = if(isnull(trees_final) == 0, abs(new_slope - 10.0), new_slope)"
```





Accumulated Cost Map Computer GIS Analysis

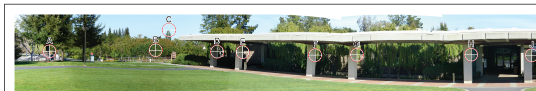


- From a given starting point, compute the "cost" to reach all other points in the search area.
- Low cost areas are more likely to contain the missing subject.

Higher Cost	Lower Cost
Steep Terrain	Road & Trails
Far Away	Flat Terrain
Dense Vegetation	Close By
Uphill	Downhill

http://www.innovativegis.com/basis/MapAnalysis/Topic19/Topic19.htm

Practice sighting bearings



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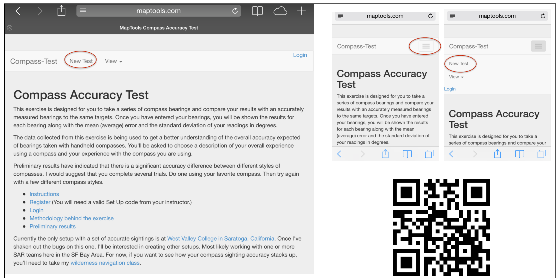
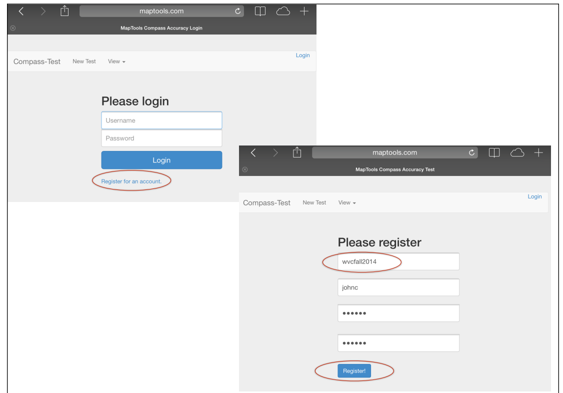
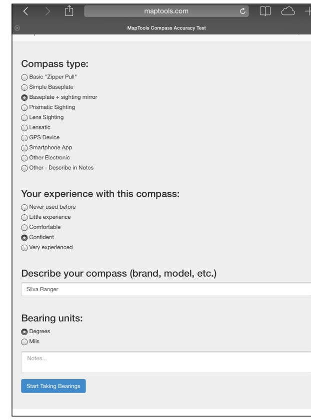
G - Column **H** - Column **J** - Column

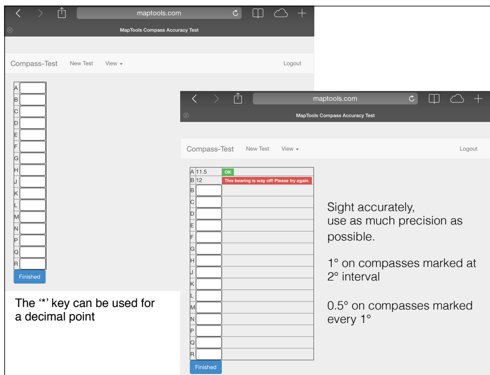
There are 18 targets to sight.



Online data collection & analysis
Point your browser to
maptools.com/compass-test
or use the QRCode on the handout.







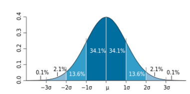
maptools.com

maptools.com/compass-test/test/view/37

WVC Lot 2 East End

Date: 11/03/2014
User: johncarnes
Compass: Silva 54

Bearing	Actual Bearing	Sighted Bearing	Difference
A	11.2	11.5	0.3
B	37.4	38.0	0.6
C	59.2	60.0	0.8
D	63.4	64.0	0.6
E	107.1	108.0	0.9
F	109.9	110.5	0.6
G	136.5	138.0	1.5
H	137.4	138.5	1.1
J	187.1	189.0	1.9
K	201.8	203.0	1.2
L	216.0	217.0	1.0
M	238.4	243.0	4.6
N	267.8	268.5	0.7
P	280.0	280.5	0.5
Q	306.7	307.0	0.3
R	329.6	330.0	0.4
		Mean	1.1
		Standard Deviation	1.4



Layout ID	Test ID	User	Compass	Mean	Standard Deviation
1	1	johncarnes	Brunton 54LU	0.1	0.5
4	15	johncarnes	54LU	0.0	0.8
4	12	johncarnes	Brunton Eclipse Mirrored	-1.0	1.3
1	4	johncarnes	Brunton Sightmaster	-0.1	1.7
1	9	johncarnes	Cammenga 3H	-0.5	1.8
1	3	johncarnes	Silva Ranger	-0.1	1.9
4	11	johncarnes	Francis Barker M-73	1.8	2.0
1	7	johncarnes	China Black Sighting	-0.6	2.3
4	14	johncarnes	Brunton Eclipse GPS	-0.5	2.6
1	8	johncarnes	Francis Barker M-73	1.8	2.9
4	13	johncarnes	Celestron w/ Glasses	-3.3	3.5
4	10	johncarnes	iPhone 4S Theodolite Pro app	1.1	5.2

How I measured accurate bearings

- Used differential GPS to find a 90°T base line (~210m)
- Used surveyors total station to transfer bearings from the baseline to two points outside of the classroom.
- Used total station to sight bearings to targets.
- Overall accuracy +/- 0.2° based on the baseline accuracy.
- Targets measured relative to the baseline +/- 0.01°.

Compass Test Sheet

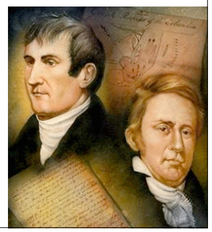
Field Exercise

- Practice sighting bearings
- Return to classroom in 45 minutes.

Public Land Survey System

"Your observations are to be taken with great pains and accuracy, to be entered distinctly and intelligibly for others as well as yourself to comprehend all the elements necessary, with the aid of the usual tables, to fix the latitude and longitude of the places at which they were taken"

– Letter from President Thomas Jefferson to Meriwether Lewis June 20, 1803



Why The Need For The PLSS

- Replace older land description system
- Cover vast amounts of land
- Enable westward migration
- Uniform method to describe and convey land titles
- Easy for a lay person to locate a parcel of land

Land Ordinance Act

- Land Ordinance Act on May 20, 1785, by the Continental Congress
  – Be it ordained by the United States in Congress assembled, that the territory ceded by individual states to the United States, which had been purchased of the Indians inhabitants, shall be disposed of in the following manner: A surveyor from each state shall be appointed by congress or a committee of the states, who shall take an oath for the faithful discharge of his duty, before the Geographer of the United States, who is hereby empowered and directed to administer the same; and the surveyor under whom he acts.

  – First Geographer of the United States "Thomas Hutchins"

Beginning Point of the U.S. Public Land Survey

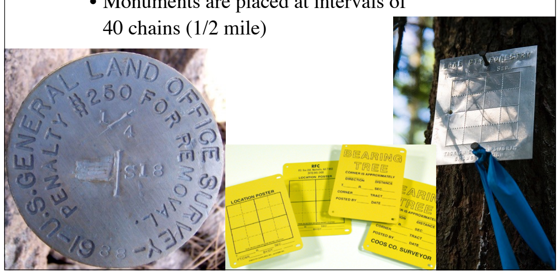
The Survey began in 1785.

In the Field

- Contracts for survey work were awarded to deputy surveyors by competitive bid.
- The deputy surveyor, with a crew of chainmen, axemen, and a compassman, ran the survey lines in the field and was responsible for erecting survey monuments, marking "bearing trees," and recording all measurements in his field notes.
- The deputy surveyor's work was verified by the surveyor general, and the field notes and plats submitted to the commissioner of the GLO for approval.

Base Line

- Base line is extended east and west on a true parallel of latitude
  - Monuments are placed at intervals of 40 chains (1/2 mile)



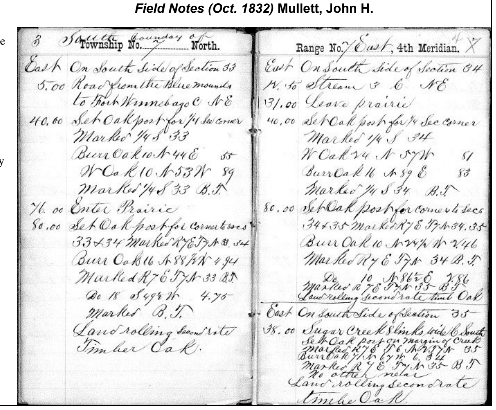
Principal Meridian

- True meridian that is astronomically determined and is extended from the initial point, north and south.
  - Monuments are placed at intervals of 40 chains (1/2 mile)

Field Notes (Oct. 1832) **Mullett, John H.**

Section Line

Wisconsin Township 7 North Range 7 East Section 33 S. Boundary



Public Land States

- Alabama
- Alaska
- Arizona
- Arkansas
- California
- Colorado
- Florida
- Idaho
- Illinois
- Indiana
- Iowa
- Kansas
- Louisiana
- Michigan
- Minnesota
- Mississippi
- Missouri
- Montana
- Nebraska
- Nevada
- New Mexico
- North Dakota
- Oklahoma
- Ohio
- Oregon
- South Dakota
- Utah
- Washington
- Wisconsin
- Wyoming

Congressional Acts

- 1812
  - Created the General Land Office
- 1849
  - Congress established the Department of the Interior
- 1946
  - Abolished the General Land Office and Created the Bureau Of Land Management

Land Grants and Ranchos

- As part of the settlement of the Mexican War of 1846-1848, "ranchos," or private land holdings established during Spanish and Mexican rule, were honored by the U.S. Government under the Treaty of Guadalupe Hidalgo with Mexico.
- These ranchos, which were primarily along coastal areas of present-day California and in the San Joaquin and Sacramento Valleys, covered 9 million acres, or 14,000 square miles.

Land Grants and Ranchos

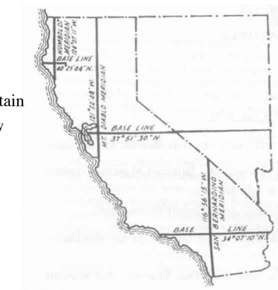
- To delineate these private lands, the United States Deputy Surveyors were assigned to survey the rancho boundaries.
- During the 1850s more than 30 government survey parties were deployed.

Initial Point

- Surveying the public lands in California was no easy task.
- Because of the size of the state and the steepness of terrain in many areas of California, the Surveyor General of the United States decided that three initial points were needed.

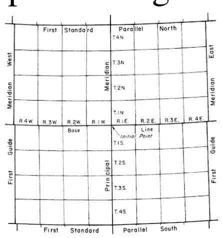
Initial Points for California & Nevada

- Mt. Diablo
  - Contra Costa County
  - 1851
- San Bernardino Mountain
  - San Bernardino County
  - 1852
- Mt. Pierce
  - Humboldt County
  - 1853.



Township and Ranges

- 6 miles square

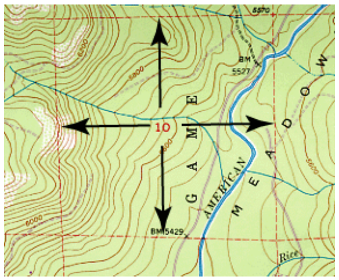


Sections

- 1 mile square
- 640 acres

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

Section 10



School Section

- Sections 16 and 36 of every township were usually deeded to the State.
- Section 16, the *school section*, was leased to generate funds to support public schools.
- Section 36 was leased to fund state government operations.

Homestead Act of 1862

- Allowed anyone to file for a quarter-section of free land.
- The land was yours at the end of five years if…
  - you had built a house on it
  - dug a well
  - broken (plowed) 10 acres
  - fenced a specified amount
  - and actually lived there

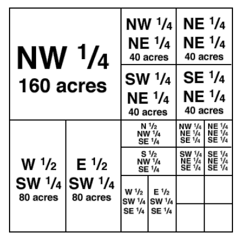
Homestead Act of 1862

- Additionally, one could claim a quarter-section of land by "timber culture" (commonly called a "tree claim").
  - This required that you plant and successfully cultivate 10 acres of timber.

Railroad Act of 1862

- As an incentive to get railroad track built, railroad companies were granted alternate odd numbered sections of land, to the amount of five alternate sections per mile, on either side of a completed rail line.

Section Subdivisions



Roads, Fences & Monuments

- In rural areas its is common for roads and fence lines to follow section or quarter section boundaries.
- It is common to find physical “monuments” marking section and quarter section corners.