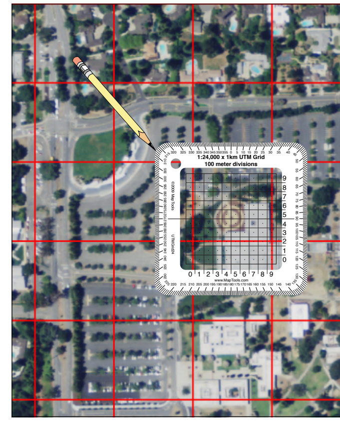
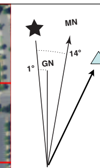
Reminders…

- Homework due on Sunday
- Quiz on Sunday
- We are here until 10pm tonight
- We start at 9am tomorrow.

1

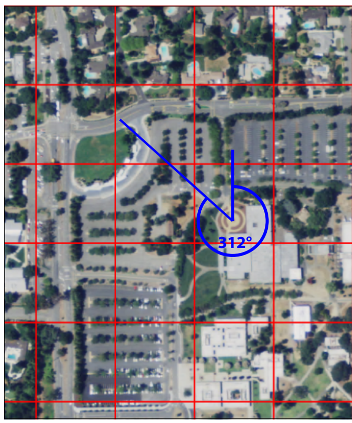
Plotting a Bearing

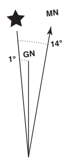
2

299° Mag. + 13° = 312° Grid

3





299° Mag. + 13° = 312° Grid

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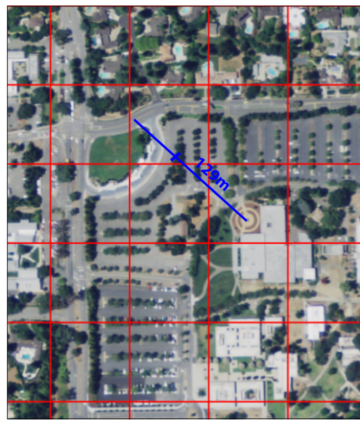
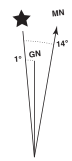




299° Mag. + 13° = 312° Grid

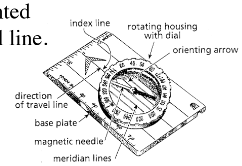
129m

5

6

Traveling Along a Heading

- Set the desired heading on the ring at the index line.
- Box the magnetic needle in the orienting arrow.
- Travel in the direction pointed to by the direction of travel line.



7

Traveling Along a Heading

- Sight to a distant object, and then travel towards that object.
- In poor visibility, darkness, or featureless landscapes, send a partner ahead to the limit of visibility and align them with the heading.
- Take back bearings on your starting point.

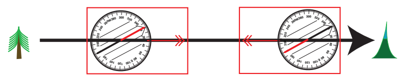
8

Using a back bearing

- A *back bearing* is taken looking back to where you took the original bearing.
- A back bearing is 180° different from a forward bearing.
- An easy technique is to align the south end of the needle rather than the north end.

9

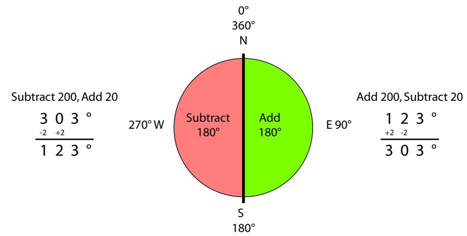
Check that you are on course using a back bearing



- Don't touch the dial
- Just align with the south end of the needle

10

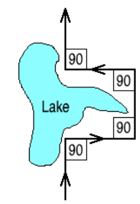
Calculating a back bearing



11

Traveling Along a Heading

- Carefully move around obstructions in the path with a perpendicular dog leg.



12

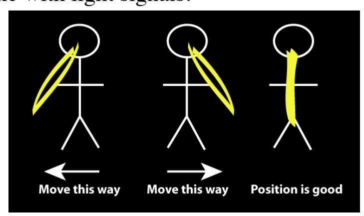
Traveling a Heading at Night

- Work with a partner.
- Send your partner ahead
- Your partner should move to a position along the heading, where they can still see you.
- Your partner should position themselves using a back bearing.

13

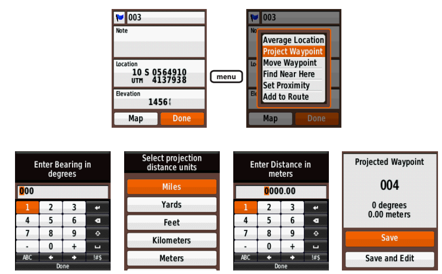
Traveling a Heading at Night

- Final positioning along the heading should be done with light signals.



14

Bearing & Distance by Projecting a Waypoint



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Skills Review

- Plot a UTM coordinate
- Enter a new waypoint into your GPS
- Follow a compass bearing for a given distance
- Plot a bearing on your map
- Take a bearing on an object
- Use a lat/lon coordinate in your GPS

16

Skills Review

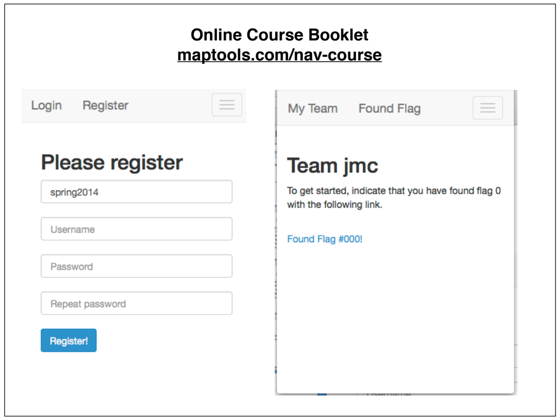
- Solve a Sudoku puzzle
- Think before you act
- Map before you go
- Recognize poison oak
- Work with a partner

17

A few notes...

- Check out and then back in on the sheet
- Letter Punches & Flag Cards
- False Flags

18



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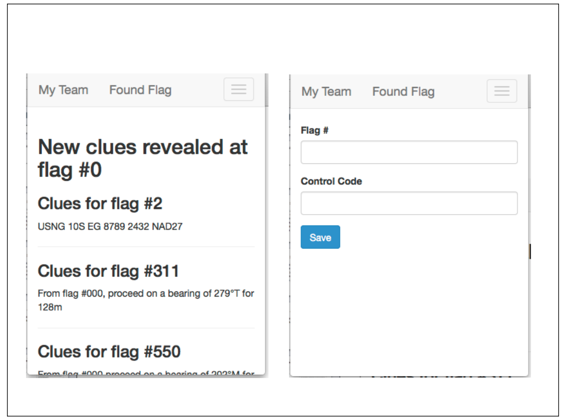

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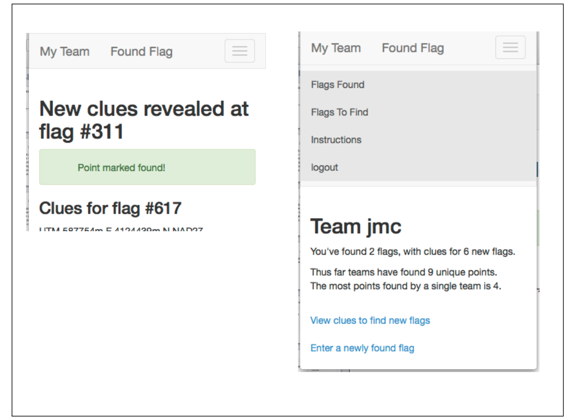

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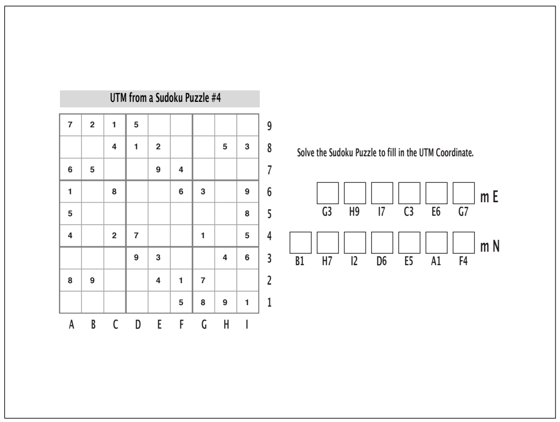

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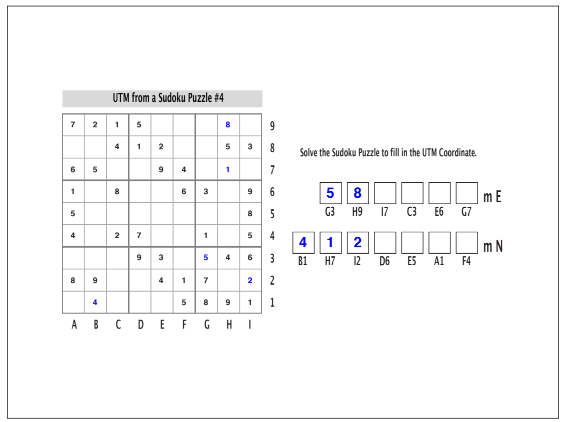

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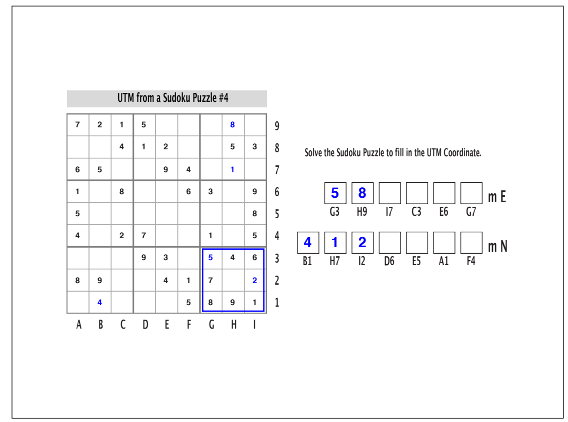

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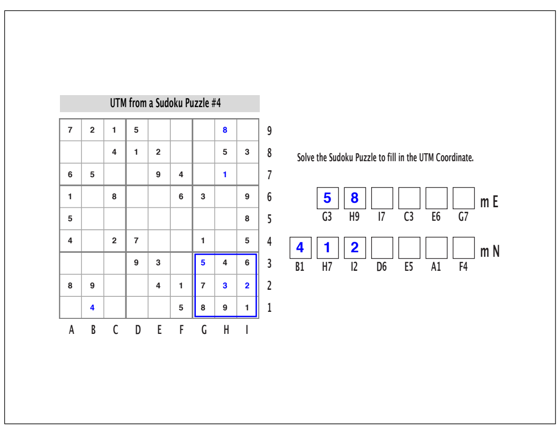

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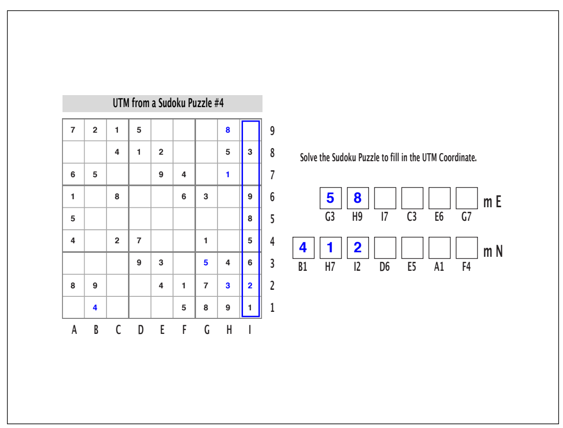

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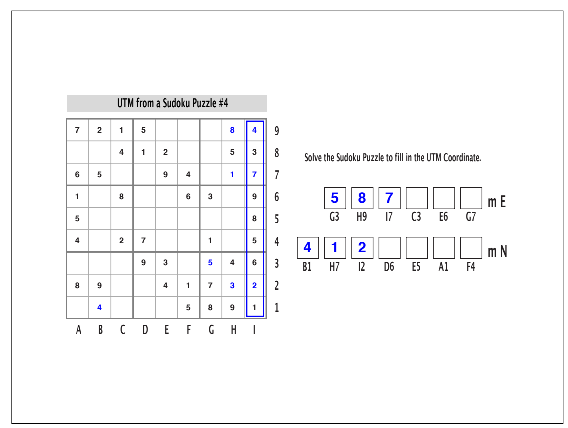

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UTM from a Sudoku Puzzle #4

A	B	C	D	E	F	G	H	I	
7	2	1	5				8	4	9
		4	1	2			5	3	8
6	5			9	4		1	7	7
1		8			6	3		9	6
5								8	5
4		2	7			1		5	4
			9	3		5	4	6	3
8	9			4	1	7	3	2	2
	4				5	8	9	1	1

Solve the Sudoku Puzzle to fill in the UTM Coordinate.

5	8	7				m E
G3	H9	I7	C3	E6	G7	

4	1	2					m N
B1	H7	I2	D6	E5	A1	F4	

28

UTM from a Sudoku Puzzle #4

A	B	C	D	E	F	G	H	I	
7	2	1	5				8	4	9
		4	1	2			5	3	8
6	5			9	4		1	7	7
1		8			6	3		9	6
5								8	5
4		2	7			1		5	4
			9	3		5	4	6	3
8	9	5	6	4	1	7	3	2	2
	4				5	8	9	1	1

Solve the Sudoku Puzzle to fill in the UTM Coordinate.

5	8	7				m E
G3	H9	I7	C3	E6	G7	

4	1	2					m N
B1	H7	I2	D6	E5	A1	F4	

29

UTM from a Sudoku Puzzle #4

A	B	C	D	E	F	G	H	I	
7	2	1	5	6	3	9	8	4	9
9	8	4	1	2	7	6	5	3	8
6	5	3	8	9	4	2	1	7	7
1	7	8	4	5	6	3	2	9	6
5	6	9	3	1	2	4	7	8	5
4	3	2	7	8	9	1	6	5	4
2	1	7	9	3	8	5	4	6	3
8	9	5	6	4	1	7	3	2	2
3	4	6	2	7	5	8	9	1	1

Solve the Sudoku Puzzle to fill in the UTM Coordinate.

5	8	7	7	5	2	m E
G3	H9	I7	C3	E6	G7	

4	1	2	4	1	3	9	m N
B1	H7	I2	D6	E5	A1	F4	

30

Google Photo

Course Record

Campus Orienteering Exercise

31

32

Thoughts on buying a GPS

- Basic features
  - Coordinate display with UTM as an option
    - Rules out most car nav models
  - Fast start up, good receiver technology
  - Easy to use user interface
    - Hard to quantify
  - USB interface
    - Almost all have this now
  - Mass Storage Mode

33

Thoughts on buying a GPS

- Optional but useful…
  - GNSS Support GLONASS, etc.
  - Digital Compass
  - External Antenna Input

34

Thoughts on buying a GPS

- Doubtful usefulness… [IMHO]
  - Uploadable maps [why?]
  - Unit to Unit data transfer
  - Altimeter
  - Camera
  - MP3 player
  - 2 Way radio

35

Physical & Performance

- Unit dimensions & Weight
- Display size
- Display resolution
- Display type
- Battery & Battery life
- Waterproof & Floats
- High-sensitivity receiver
- Interface (Serial, USB, NEMA 0183, Bluetooth)

36

Maps & Memory

- Basemap
- Preloaded maps
- Ability to add maps
- Built-in memory
- Accepts data cards

- Waypoints/favorites/locations
- Routes
- Track log

37

Features & Benefits

- Automatic routing (turn by turn routing on roads)
- Electronic compass: (tilt-compensated, 3-axis)
- Touchscreen
- Barometric altimeter
- Camera
- Geocaching-friendly
- Custom maps compatible
- Photo navigation (navigate to geotagged photos)
- Outdoor GPS games, Hunt/fish calendar, Sun and moon information, Tide tables
- Area calculation
- Custom POIs (ability to add additional points of interest):
- Unit-to-unit transfer (shares data wirelessly with similar units):
- Picture viewer
- Garmin Connect™ compatible
  (online community where you analyze, categorize and share data)

38

eTrex 10 $120

- Good basic GPS + GNSS
  - 2011 Technology
- Smallish monochrome screen
- USB interface
- Basemap only

39

eTrex 20 $200 [+$80]

- Higher resolution color screen
- Ability to add maps
- Map memory + Data card slot

40

eTrex 30 $300 [+$100]

- Electronic compass
- Barometric altimeter
- Wireless unit-to-unit transfer

41

GPSMAP 64 $300

- Basic High Sensitivity GPS+GNSS
  - 2013 technology
  - bigger screen than the eTrex
  - shorter battery life
- GPSMAP 64s $400 [+$100]
  - Compass + Altimeter
  - Wireless Unit to Unit data transfer
- GPSMAP 64st $500 [+$100]
  - pre loaded topo maps - not 1:24,000 detail

42

Dakota 10 $300

- Entry level color touchscreen
- Bigger display than eTrex
- Shorter battery life
  - 20 hrs vs 25 hrs
- Ability to add maps

43

Dakota 20 $350 [+$50]

- Electronic compass
- Barometric altimeter
- Data card slot
- Wireless unit-to-unit transfer

44

Montana Series

- Montana 600 $550
  - Big color touchscreen
  - 3 AA batts. 22 hrs
  - Compass + Altimeter
  - Wireless transfer
- Montana 650 $630 [+$80]
  - 5 Mp Camera
- Montana 650t $700 [+$70]
  - Preloaded US topo maps (Not 1:24,000 scale detail)

45

Monterra $650

- Android OS + MultiTouch Interface
- WiFi, FM Radio, Weather Radio
- 8 megapixel autofocus camera
- 1080p HD video
  – with automatic geotagging,
- LED flash/torch
- 3D MapMerge™
  – for multiple maps in 3-D

46

Smart Phone GPS

47

MotionX-GPS
iPhone App

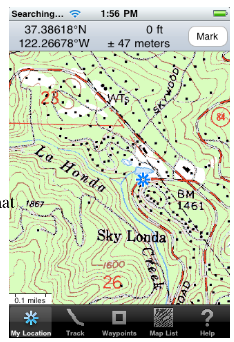
gps.motionx.com
$2.99 from the appStore

48

iHikeGPS
iPhone App

www.ihikegps.com
$7.99 from the appStore

Free map downloads
Store up to 200 maps for offline use
Mark / GOTO waypoints
Email tracks and waypoints in GPX format
Elevation profile



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Your Navigation Tool Kit

- Orienting yourself and your map
- Locating yourself on your map
- Planning and finding your route

50

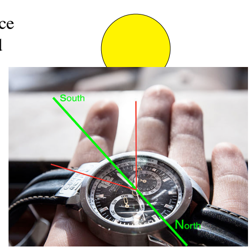
Orienting Yourself and Your Map

- Use your compass
  – the easy and obvious method
- Use the surrounding terrain to orient your map
- Use the Sun
  – Rises in the “east” and sets in the “west”
  – Use the time of day and a watch face
  – Use a shadow stick
- Use the North Star

51

Use the Time of Day and a Watch Face to Find North

Northern Hemisphere
- Point the hour hand at the sun.
- A line from the center of the watch face half way between 12 and the hour hand will point South.
- Use 1 instead of 12 when Daylight Savings Time is in effect.
- Digital watch, draw a watch face, on a scrap of paper.
Southern Hemisphere
- Swap 12 and the hour hand. (12 at the sun)
- North is the line halfway between



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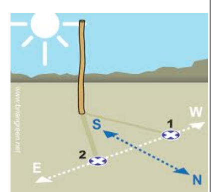
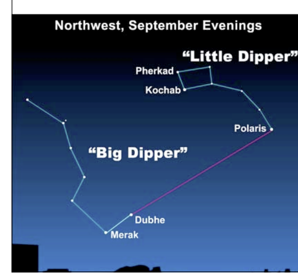
Finding North with a Shadow

- Mark the position of the end of the shadow cast by a stick. (a ski poll, walking stick, etc.)
- Wait at least 15 minutes.
- Mark the position of the end of the shadow cast by a stick again.
- The line between the marks runs approximately East-West. In the Northern Hemisphere, The first mark will be to the West of the second mark.



53

Find North using the North Star



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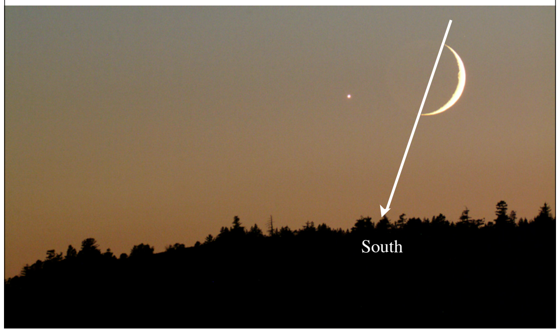
Using the "Horns of the Moon"



55

Locating Yourself on Your Map

- GPS Coordinates
  - or bearing and distance to known waypoints
- Observation of terrain and man made features
- Compass resection
- Altitude and terrain feature intersection
- Combinations of the above techniques

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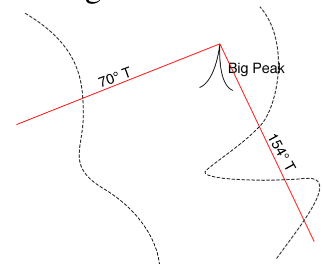
Bearing to known point intersecting with a known feature



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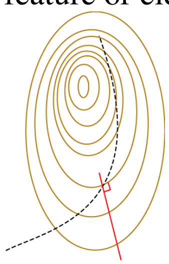
The fall line intersecting with a known feature or elevation

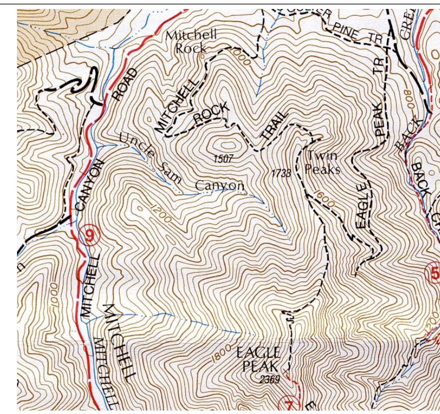


58

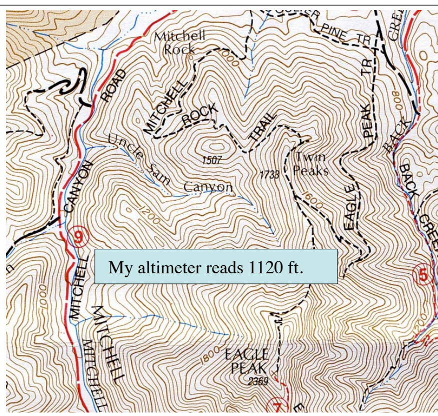
Using an Altimeter to Determine Your Location

- I'm hiking up Uncle Sam Canyon and want to know where I am on the map.
- I can't see out of the canyon to sight on anything with my compass.
- The canyon wall are blocking GPS signals.

59



60



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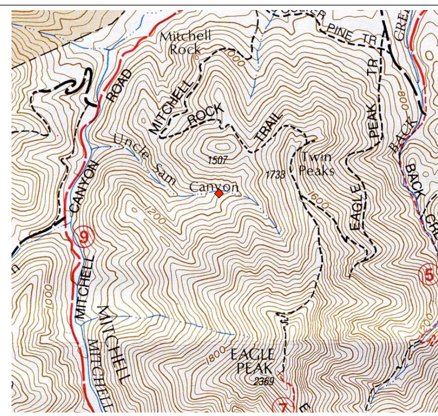

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Altimeters

- Altimeters are just barometers that read in feet or meters.
- The work by measuring changes in air pressure.
- A good altimeter can indicate elevation changes a small as 10 ft.
- They can be mechanical or electronic
- They should be temperature compensated

63

Altimeters must be calibrated

- Changing weather patterns cause the air pressure at any given location to change over time.
- You must set you altimeter while you are at a know elevation.
- You must set it at least every day
- When the weather is changing, you need to set it more often.

64

Using your altimeter to determine your position

- You need to be on an identifiable route on the map
  - Trail, drainage, glacier, hillside, etc.
- Works best with steady elevation gain or loss.
- There will be more position possibilities if you are going up and down in elevation.

65

Route Planning & Finding

66

Factors Driving Your Plan

- Avoiding hazards
- Destination & schedule
- Avoiding difficult terrain & vegetation
- Fastest, Shortest, Easiest
- Area Coverage or Avoidance

67

Time Factors

- Many a trip has turned into a disaster because a pressing need to "get back in time" didn't fit with a route that took longer than planned.
- If you "gotta be back on time" leave plenty of extra time for the unexpected.
- Plan in a few bailout possibilities, and some guidance about when to use them. "Choice Points"

68

The Drive Home

- Don't forget that it's often the drive home that is the most dangerous part of the trip.
  - You're tired, maybe you didn't sleep well on the ground…
  - It's a long and windy road back out of the mountains…
  - It's usually late afternoon, or even later…

69

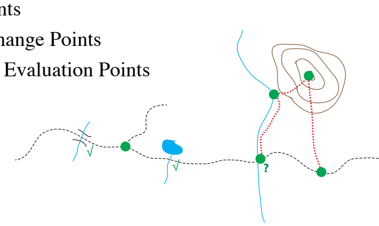
On Trail v.s. Off Trail

- Tradeoff additional distance for potential savings in time and ease of travel
  - A 1.5 to 2.0 X distance is an "easy" trade in most conditions.
  - Difficult cross country travel conditions will weight on-trail travel even more favorably.

70

Building a Navigation Story

- Story Components...
  - Course Legs
  - Checkpoints
  - Course Change Points
  - Choice or Evaluation Points



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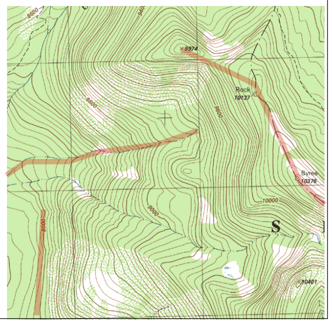
Man Made Linear Features

- Roads & Trails
- Fences
- Power lines
- Walls

72

Using Terrain Breaks as Linear Features

- Where the slope of the terrain makes an obvious change.
  - Uphill / Downhill
  - Flat / Steep



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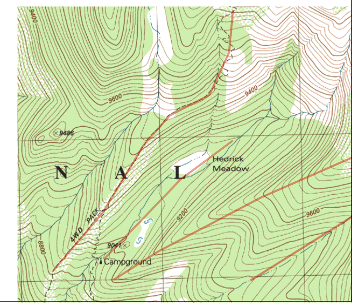
Natural Linear Features

- Rivers
- Creeks and streams
- Shorelines
- Vegetation transitions, forest to grass, etc.

74

Handrails

- Linear features along your route of travel that you can see and follow.



75

When You Hike on Trail…

- You are using a network of handrails.
- You can make that network a whole lot bigger, when you learn to use terrain features as handrails.

76

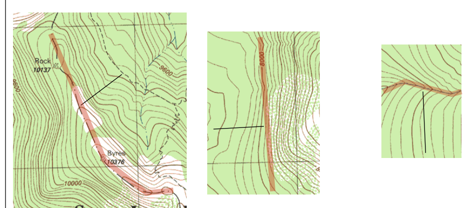
Options when you don't have a handrail

- Hike towards an object you can see.
- Hike along a compass bearing or in a general direction.
- Hike along a contour.
  - Without some sort of "aid" you will likely walk in an arc, which will eventually turn into a large circle.

77

Catching Features

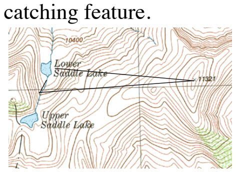
- Linear features perpendicular to your direction of travel that you can identify.
- Use them to signal a course change point.



78

Deliberate Course Offset

- Aiming to one side or the other of your goal positioned along a catching feature.
- Then you know which way to turn when you reach your catching feature.



Plan on errors of…
±5° (±100m for every 1km) casual travel
±2° (±40m for every 1km) careful travel

79

Options when you don't have a good catching feature.

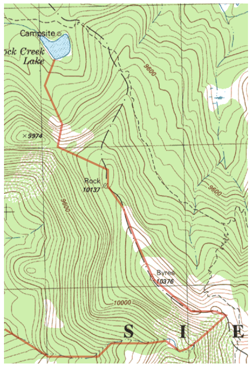
- Use time to estimate distance.
- Count paces to estimate distance.
- Use an altimeter and select a "catching elevation."
- Use a bearing to a distant object.
- Use the visual alignment of two objects.

80

Use timing for distance

- It's best if you can establish your speed in the field under the current conditions.
  - Time how long it takes to travel a kilometer.
- Use 15-20 min/km plus 2min per 40 ft. elevation gain, until you have better measurements.

81



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Attack Point

- Something easy to find, nearby something hard to find.
- Easy navigation to the attack point, detailed navigation from there.

83

Bailout Features

- Is there a general direction of travel that will eventually lead to "safety"
  - Roads, Shorelines, City Limits
- "Go West and downhill and you will eventually reach State Hwy. 1"

84

Sharktooth Peak Bailout Possibilities

6 miles

85

Route finding in challenging conditions is harder

- Darkness, Fog, Snow, Whiteout, etc…
  - We can't see the hazards.
  - We don't feel "comfortably on route" because we may not be able to see our checkpoints and handrails.
  - We're not sure when we'll recognize our catching features or our course change points. We're afraid we'll miss them.

86

What to do…

- Use very distinct handrails
  - Large terrain breaks
  - Roads and well defined trails
- Select "hugely obvious" catching features that are perpendicular to your direction of travel.
- Plan for larger navigational errors.

87

What to do…

- Use your GPS
  - Make waypoints for decision points were you change from one route of travel to another
  - On long legs, make "on route" waypoints to reinforce your route confidence.

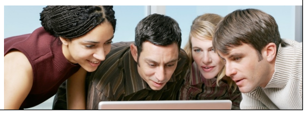
88

Partner up and try planning a virtual hike on the Sharktooth Peak map using what we just discussed

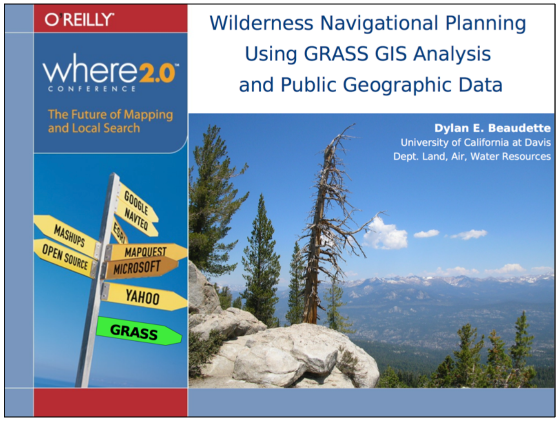
It's already been a long hard day of cross country hiking. You are tired and a bit damp. It's 2pm on a Sunday in October. You have an important meeting at work tomorrow, so you need to be back to the trailhead at Lake Eddison before dark. (6pm ish) Then you have a long late drive back to the Bay Area. The first snow of the season has been falling for the last several hours and there is about 4 inches on the ground. Visibility is poor, maybe a kilometer or less.

Plan your hike back to Lake Thomas Edison
You have a map and a compass, but no GPS.
Plan short course legs of 1km or less.
Avoid dangerous terrain.
Confidence building checkpoints are good.
Use terrain breaks as handrails and catching features.
Don't count on being able to find roads and trails under the snow.

Will you make it back before dark?

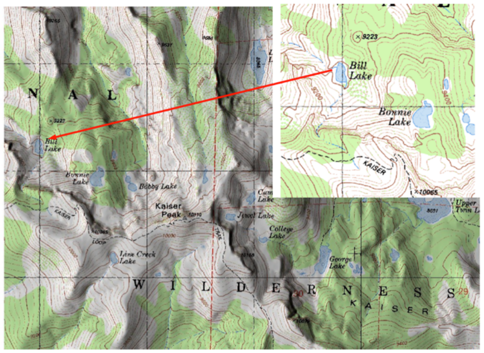


89



90

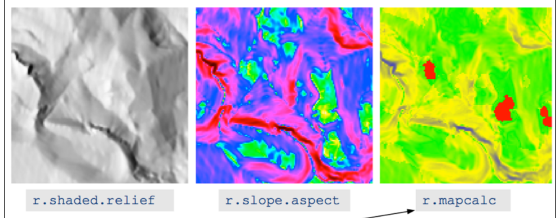
GRASS Basics: Planning a Wilderness Adventure



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

91

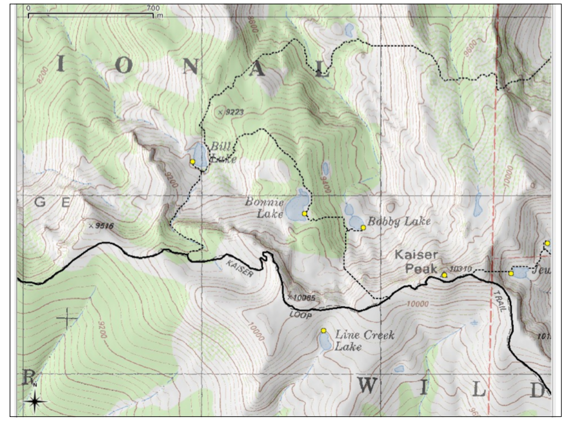
GRASS Basics: Generate Travel "Friction" Map



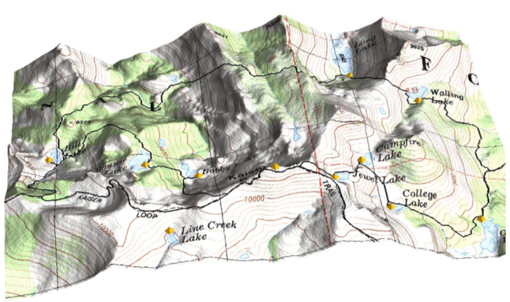

```
#update our slope map, to include traversing water features, and prefering wooded areas
#add a "cost" of 1000 to lake areas
r.mapcalc "new_slope = if(isnull(lakes) == 0, 1000.0+slope, slope)"

#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)"
```

92

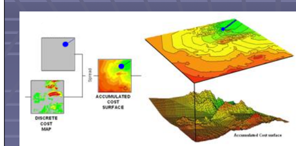


93



94

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

95

More Useful GPS Techniques

96

Routes

- A sequence of waypoints defines a route.
- First your GPS will navigate you to the nearest point on the route.
- Then your GPS will navigate you to each waypoint in the route sequence.
- It is still only straight lines from waypoint to waypoint.

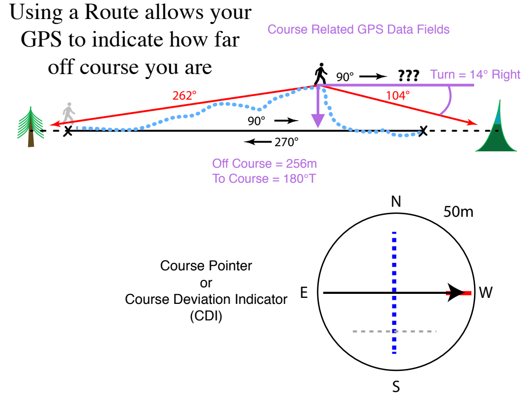
97

Routes

- A route containing your course change points can help you to avoid missing them. Especially in low visibility conditions.
- Pre-planned "safety routes" may be useful for getting down off the mountain, while avoiding hazards.

98

Using a Route allows your GPS to indicate how far off course you are



99

About the Course Pointer
The course pointer is most useful if you are navigating on water or where there are no major obstacles in your path.

The course pointer ① indicates your relationship to a course line ② leading to the destination. The course line to your destination is based on your original starting point.

As you drift from the intended course to the destination, the course deviation indicator ③ (CDI) provides the indication of drift (right or left) from the course.

The scale ④ refers to the distance between dots on the course deviation indicator.

Navigating with the Course Pointer
Before you can navigate with the course pointer, you must change the pointer setting to **Course (CDI)** (page 34).

Heading Settings
This function is available on the eTrex 30.

Select **Setup** > **Heading**.

- **Display**—sets the type of directional heading on the compass.
- **North Reference**—sets the north reference of the compass.
- **Go To Line (Pointer)**—allows you to select how the course appears.
  - **Bearing** (**Small** or **Large**)—sets the direction to your destination.
  - **Course (CDI)**—the course deviation indicator displays your relationship to a course line leading to a destination.

100

Customizable Data Fields

Accuracy of GPS
Ambient Pressure
Ascent - Average
Ascent - Maximum
Ascent - Total
Barometer
Battery Level
Bearing
Cadence (cadence accessory required)
Course
Descent - Average
Descent - Maximum
Descent - Total
Distance to Destination
Distance to Next
Elevation
Elevation - Maximum
Elevation - Minimum
ETA at Destination
ETA at Next
Glide Ratio
Glide Ratio to Dest.
GPS Signal Strength
Heading
Heart Rate (heart rate monitor required)

Location (lat/lon)
Location (selected)
Odometer
Off Course
Pointer
Speed
Speed - Maximum
Speed - Moving Avg.
Speed - Overall Avg.
Sunrise
Sunset
Time of Day
Time to Destination
Time to Next
To Course
Trip Odometer
Trip Time - Moving
Trip Time - Stopped
Trip Time - Total
Turn
Velocity Made Good
Vert. Speed to Dest.
Vertical Speed
Waypoint at Dest.
Waypoint at Next

101

Map View

- Visual “Where am I on the map”
- Easier way to create waypoints
- Can show the “boundary” of an area
  - use waypoints along the boundary
  - make a custom map showing the boundary
- Track display can be used to monitor coverage of an area.

102

Geofencing

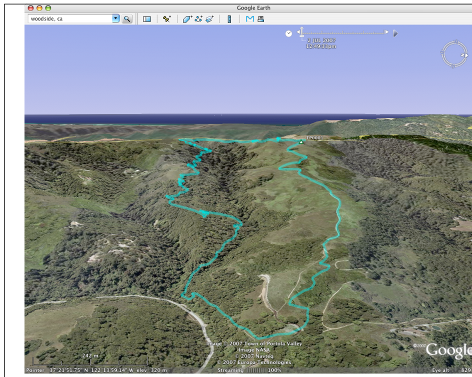
- Use a string of waypoints with overlapping proximity alarms to indicate a hazard or boundary.
  - Set proximity distance based on “safe distance from hazard” or “warning distance for approaching boundary”
  - Overlap by about twice the expected GPS accuracy, to avoid “holes in the fence.”

103

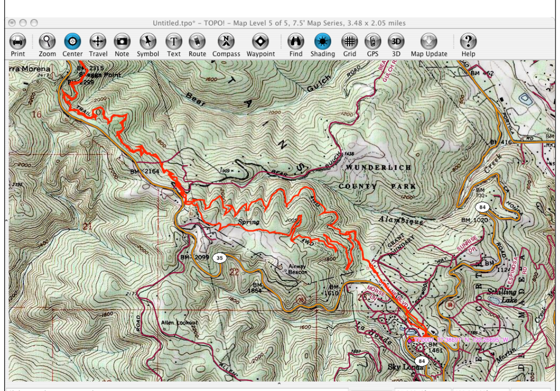
Track Logs

- Track logs can be downloaded into most computer topo map programs.
- GPS must be on and tracking for entire route to log
  - GPS unit position, must “face the sky”
  - Batteries
  - Good satellite signals
- Setup options are important

104



105



106

Track Loggers

- Standalone devices that do nothing but log a track.

107

- Timestamped photos, videos, and voice recordings can be linked to the track by their timestamp, and thus their position can be determined.
- Geotagging a Photo
- Many new digital cameras and most smartphone cameras can geotag photos and voice recordings

108

Area Calculation

- Most GPS receivers can turn a track log into a route that you can follow back to your starting point.
- IMHO, this is relying on your GPS a bit more than you should be.

109

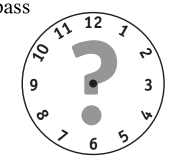
Afternoon Navigation Exercise

- Parking Lot #2 Bearing and Distance Course
  - Work with a partner
  - You will need
    - Course Sheet
    - Compass
    - Writing surface
    - Pen or pencil

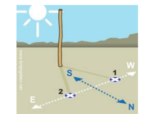
110

Afternoon Navigation Exercise

- Find North Without Using A Compass
  - Watch face method



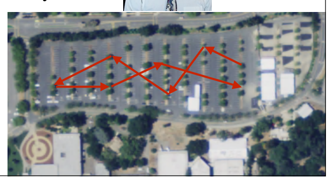
  - Shadow from a stick method



111

Afternoon Navigation Exercise

- Parking Lot #2 Bearing and Distance Course
  - Work with a partner
  - Do at least half the course with a bag over your head to simulate low visibility
  - You will need
    - 2nd course sheet
    - 2 paper bags
    - Compass
    - Writing Stuff



112

Tips for traveling along a bearing in poor visibility

- Hold the compass with both hands in front of you.
- Stop walking to correct your heading.
  - Move your feet, not just your body when correcting.

113

Afternoon Navigation Exercise

114

Afternoon Navigation Exercise

- Lot #2 Bearing & Distance
- Lot #2 Low Visibility

115

116

117

Using an unfamiliar map

- Date of information
- Intended usage
- Scale
- North Reference
  - Declination
- Coordinate References
  - Grids & Tics
  - Map Datum
- Distance & Elevation Units
- Topography
  - Contour Interval
- Language & Alphabet
- Symbols and Colors
- Overall strengths and weaknesses for your intended use

118

Just because it's on your map, doesn't mean you can go there!

- Private Property
  - Hiking, hunting, fishing are usually not OK in the United States. Roads may or may not be OK
  - Acceptable behavior varies by region and country.

119

Just because it's on your map, doesn't mean you can go there!

- Public Lands
  - Not all activities permitted
  - Some areas require permits
  - Some areas closed to public access
- Indian reservations are not public land
  - Each is likely to have it's own unique access restrictions.

120

Just because it's on your map, doesn't mean you can go there!

- Poking around military and government facilities with your nav gear, will likely draw attention from security forces.
- Your nav gear may get you arrested and jailed in some countries.

121

My Favorite Nav Books

- Navigation - Finding Your Way on Mountain and Moorland
  - Kevin Walker ~$18
- Navigation in the Mountains
  - Carlo Forte ~$19
- Ultimate Navigation Manual
  - Lyle Brotherton ~$15

122

What Can Go Wrong…

123

Change in Visibility

- Darkness
- Fog, snow, rain
- Snow covering roads, trails, and terrain

124

Passive Transport

- Hiking behind a leader, paying no attention to navigation
- Getting dropped off by vehicle or helicopter

125

Getting Separated

- One or members of a group, without good navigation skills get separated from the rest of the group.

126

Equipment Failure
You – Fatigue

- Tired, Cold, Wet, …
- All of these lead to stupid mistakes.

127

Equipment Failure

- I talk to lots of people that "don't trust" the GPS system…
- I ask them what time it is, and none of them look towards the sun or pull out a sundial.

128

Equipment Failure
GPS

- You forgot how to use it
- Dead batteries
- Device failure or loss

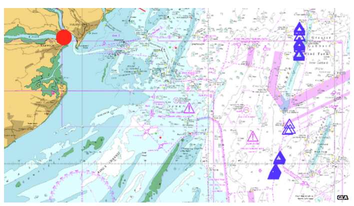
129

April 2nd 2014

Satellites of the GLONASS network experienced a half-day outage when bad data was uploaded to spacecraft.

The GLA map shows a GLONASS receiver at Harwich giving corrupted position fixes that were off by more than 50km.

The Authorities say the 2 April event is a timely reminder that alternatives to satellite navigation are essential.



A GLONASS receiver (red dot) on England's east coast gave position fixes in the North Sea (blue triangles) BBC 9/14/2014

130

Equipment Failure
Compass

- You forgot how to use it
- Poor visibility limits usefulness
- Misadjusted for declination
- Device failure or loss

131

Local Magnetic Anomalies

- May be as much as 90 degrees
  - 3-4 degrees is common
- North of Kingston, Ontario; 90° of anomalous declination.
- Kingston Harbor, Ontario; 16.3° W to 15.5° E of anomalous declination over two kilometers (1.2 miles); magnetite and ilmenite deposits.
- Savoff, Ontario (50.0 N, 85.0 W). Over 60° of anomalous declination.
- Ramapo Mountains, northeastern New Jersey; iron ore; compass rendered useless in some areas.
- Near Grants, New Mexico north of the Gila Wilderness area; Malpais lava flows; compass rendered useless.

132

Equipment Failure
Map

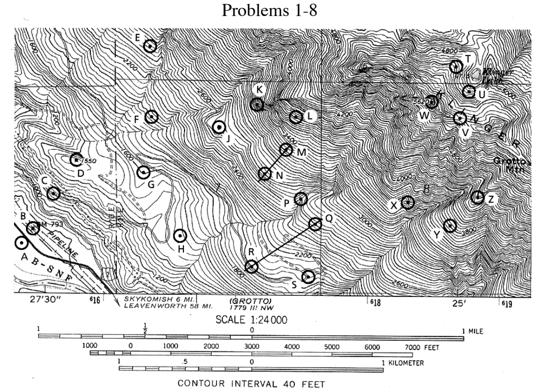
- Traveled beyond the maps carried
- Got wet - beware of water based inks
- Lost it

133

Homework Review and Questions

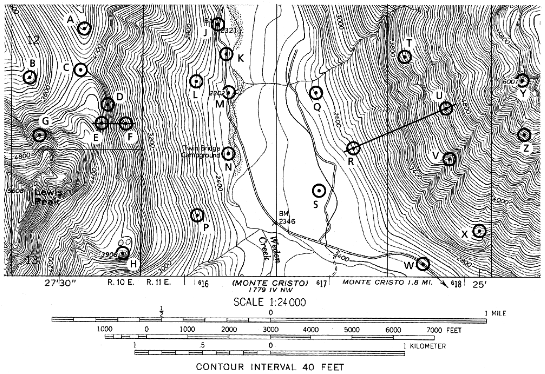
134

Problems 1-8



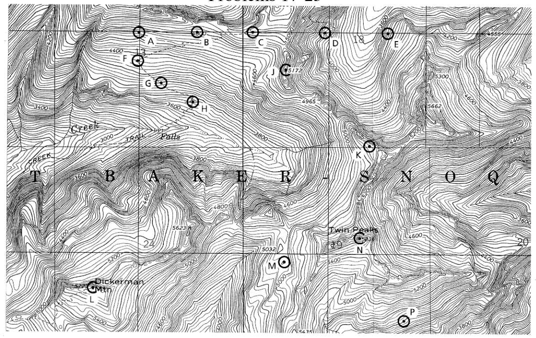
135

Problems 9-16



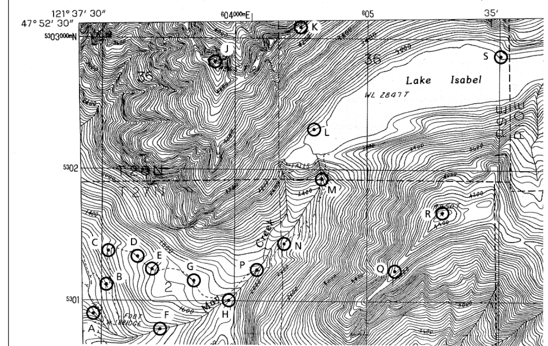
136

Problems 17-23



137

Problems 24-30



138

Low Visibility Route Finding Exercise

- Plan and follow a route to at least three campus landmarks.
- Use the bag to simulate low visibility.

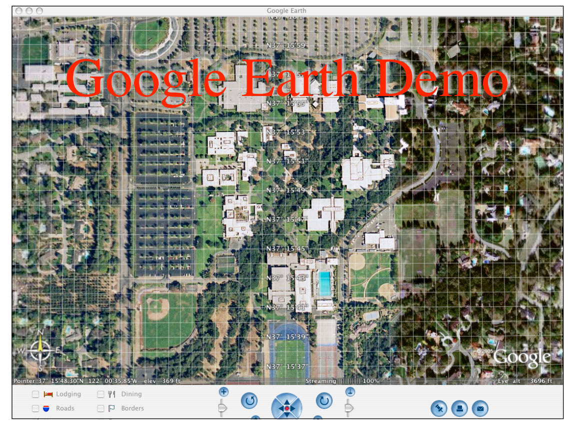
- Use
  - Checkpoints
  - Course Change Points
  - Handrails
  - Catching Features
  - Attack Points

139

Low Visibility Route Finding Exercise

- Plan Low Visibility Route & Follow it to 3 Locations
- Back to the classroom by…

140



141

USGS National Map Demo

http://viewer.nationalmap.gov/viewer/

142

Topo Map Data & Software

- Useful for...
  - Map Printing
  - Waypoint & route creation and uploading
  - Track visualization
  - Elevation profile
  - 3D visualization

143

Topo Map Data & Software

- Three Major Suppliers
  - National Geographic -- Topo!
  - DeLorme -- Topo USA
  - MapTech -- Terrain Navigator

144

Topo Map Data & Software

- National Geographic -- Topo! State Series
  - PC and Mac
  - 1:24,000, 1:100,000, and 1:500,000 scales
  - UTM or Lat/Lon Grids NAD27 or WGS84
  - GPS upload/download
  - $50 per state
- maps.nationalgeographic.com

145

Topo Map Data & Software

- DeLorme -- Topo North America
  - PC only
  - DeLorme's Vector data for entire US and Canada
  - UTM or Lat/Lon Grids NAD27 or WGS84
  - GPS upload/download
  - 3D View
  - DVD
  - $60
  - $30/yr subscription to download USGS topos
  - $30/yr subscription to download satellite imagery
- www.delorme.com

146

Topo Map Data & Software

- MapTech -- Terrain Navigator
  - PC Only
  - 1:24,000, 1:100,000, and 1:500,000 scales
  - UTM or Lat/Lon Grids NAD27 or WGS84
  - GPS upload/download
  - 3D View
  - Map Border is optionally viewable
  - $99.95 per state
- www.maptech.com

147

Converting Lat/Lon to UTM

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

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

148

Converting UTM to Lat/Lon

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

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

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

149

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

150

More about UTM

151

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.

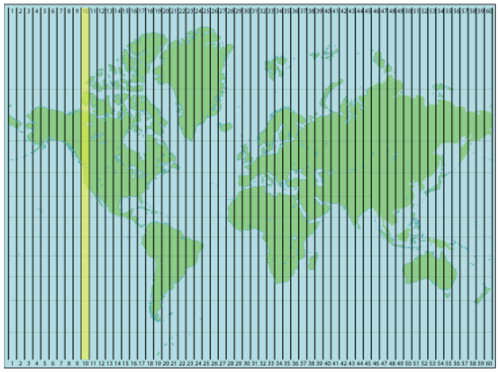
152

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.

153

UTM Zones



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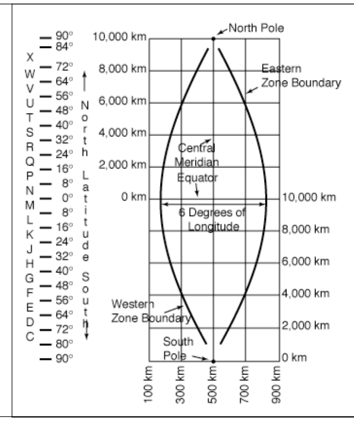
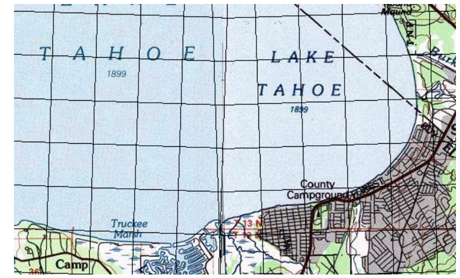
UTM Zone Details



155

Boundary between UTM zones



156

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.

157

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

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

158

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

159

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

160

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.

161

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

162

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

163

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)

164

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

165

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

166

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….

167

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

168

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

169

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.

170

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

56mm ⇔ 1km

0.056m ⇔ 1000m (convert to similar units)

$\frac{0.056m}{0.056} \Leftrightarrow \frac{1000m}{0.056}$ (divide to get a one on the left side)

1m ⇔ 17857m

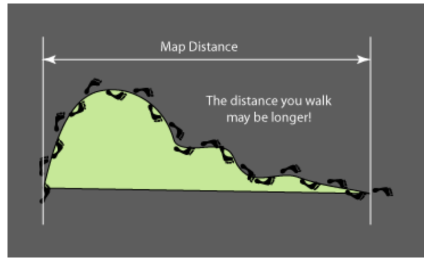
The map scale is 1:17,857

171

Measuring Distance in the Field

172

Map Distance v.s. Terrain Distance



173

Using a tape or “chain”

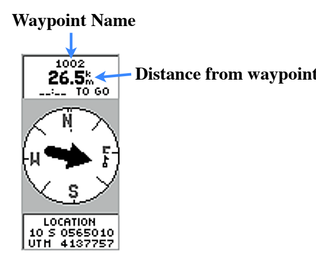
174

Other methods

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

175

GPS Distance Measurement

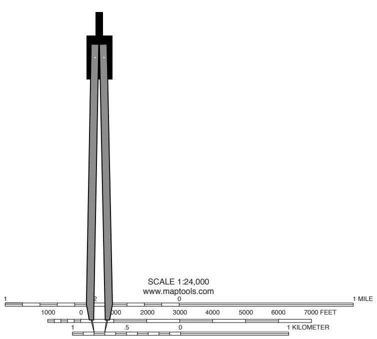


176

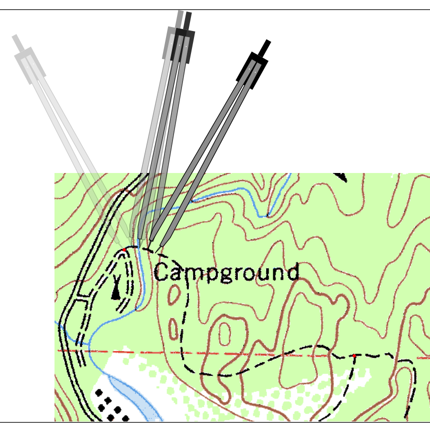
Measuring Distance on a Map

- 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.

177



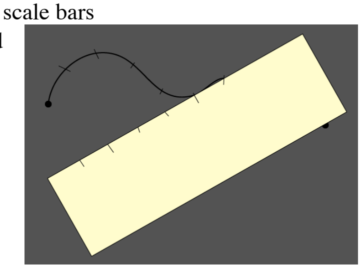
178



179

Paper Edge Technique

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



180

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!

181

Map Measuring Gadgets

182

Distance and Time

- Time is usually what we think about
- Time(minutes) = (60/Speed(km per hour)) X Distance(km)

183

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.

184

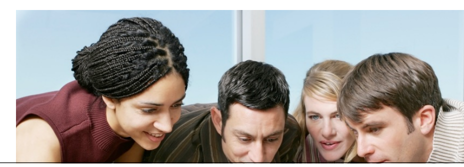
Measure in Current Conditions

- 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

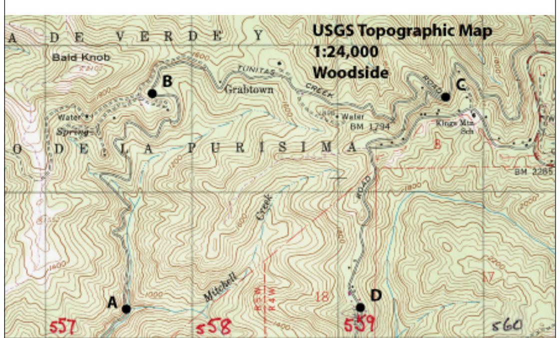
185

In class exercise on scale & distance

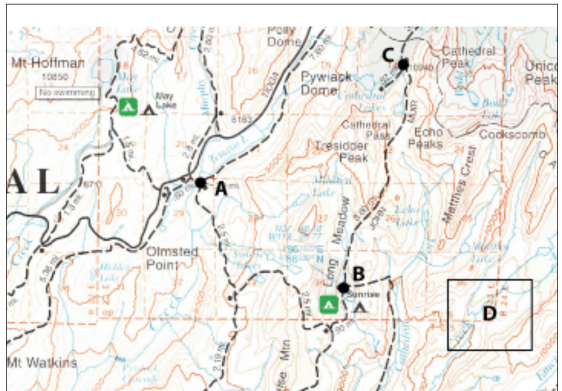
- See the handout



186



187



188

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.

189

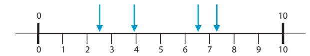
If there are no coordinates…

- 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.

190

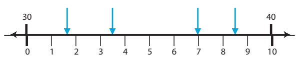
Number Line Exercise

191



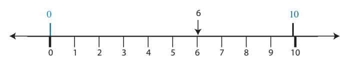
Locate and label the following points on the number line above:
4, 6.5, 7.25, and 2.368

192



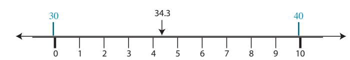
Locate and label the following points on the number line above:
37, 33.5, 31.75, and 38.465

193



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

194

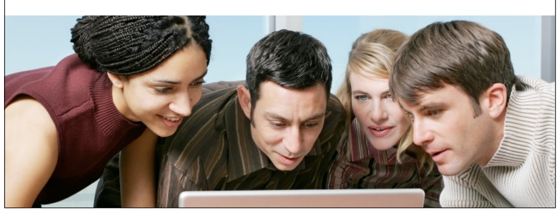


Locate and label 30 and 40 on the section of number line above.

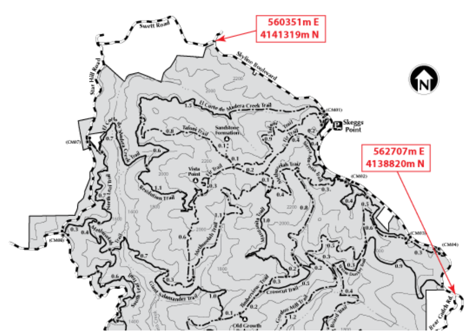
195

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.

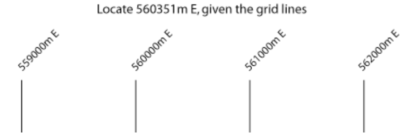


196

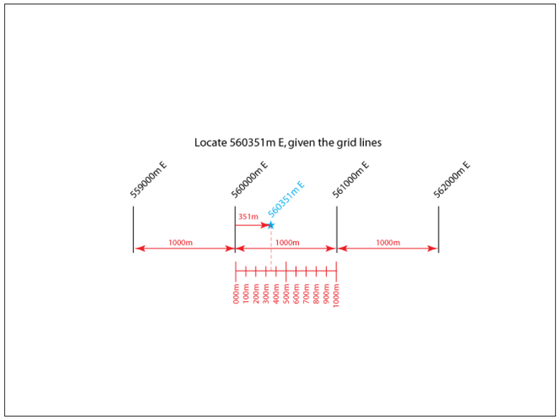


197

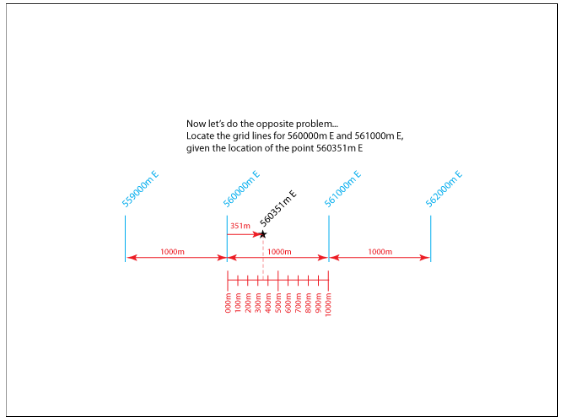
Locate 560351m E, given the grid lines



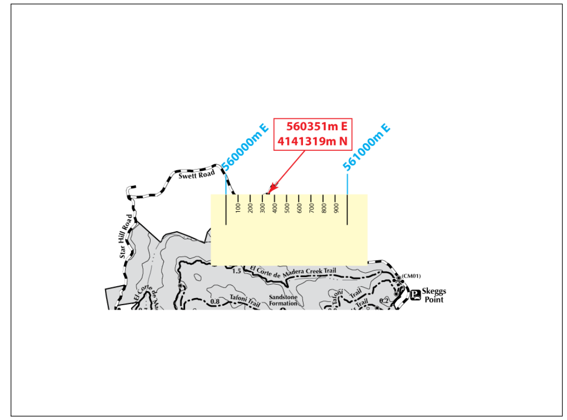
198



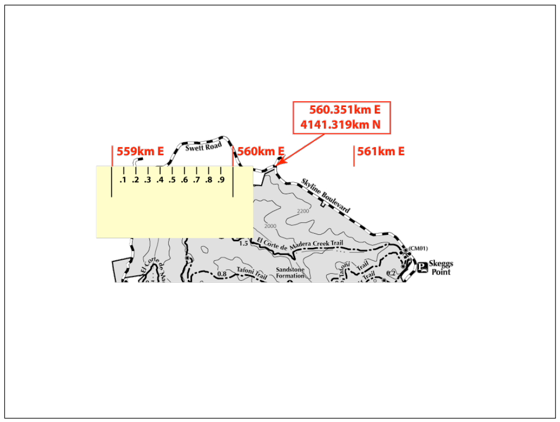
199



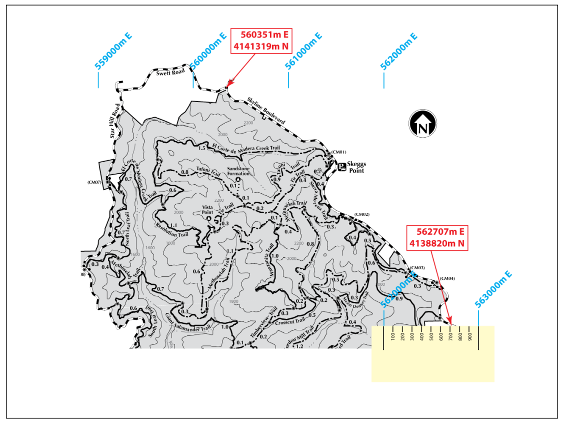
200



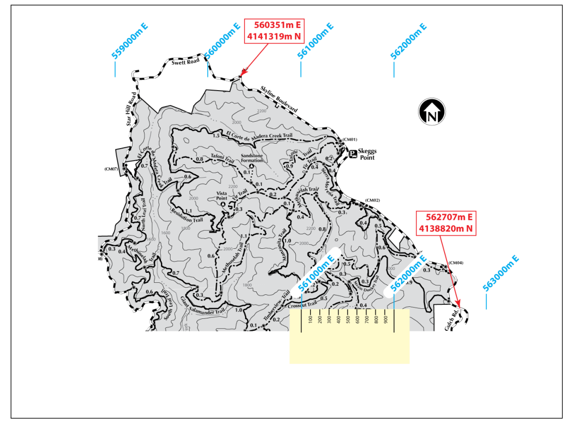
201



202



203



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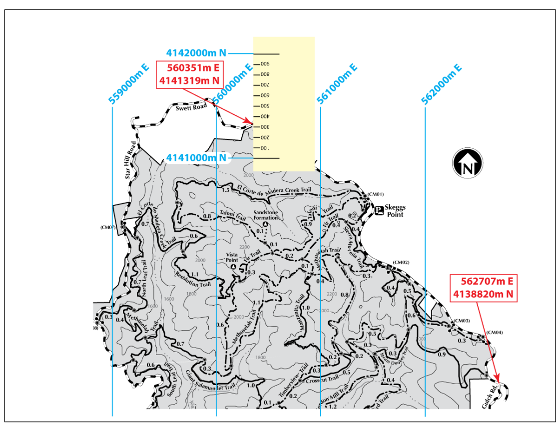

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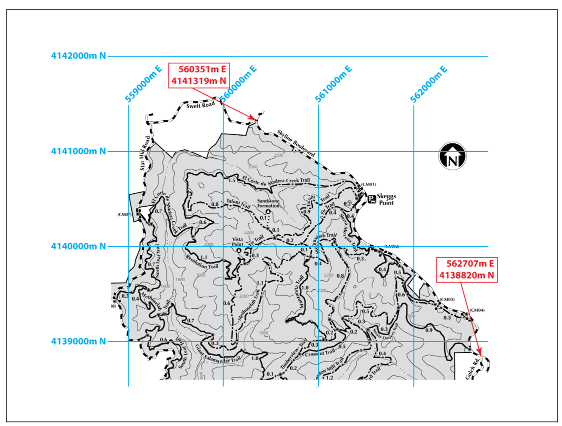
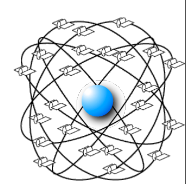


206

How the GPS System Works

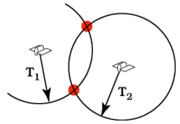
- 24 satellites + spares
- 6 orbital planes 55° inclination
- Each satellite orbits twice every 24 hours.
- At least 4 satellites visible any time of day, anywhere in the world.



207

A 2 Dimensional Example

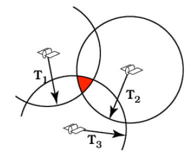
- Time for the signal to reach GPS receiver is determined.
- Distance is computed by multiplying by the speed of light.
- Distance from two satellites defines 2 points (in 2 dimensional space.)



208

A 2 Dimensional Example

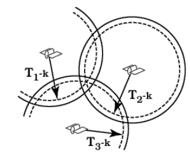
- The distance from a third satellite narrows the location to an "error triangle."



209

A 2 Dimensional Example

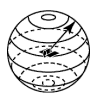
- Assume the error in each of our measurements is a constant, k.
- Solve for k, so that the "error triangle" is as small as possible.



210

Now for 3 Dimensions

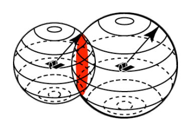
- Distance from a single satellite locates a position somewhere on a sphere.



211

Now for 3 Dimensions

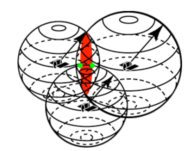
- Two measurements put the location somewhere on a circle at the intersection of the two spheres.



212

Now for 3 Dimensions

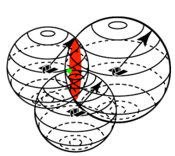
- Three measurements put the location at one of two points at the intersection of the three spheres.



213

Now for 3 Dimensions

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



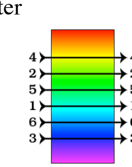
214

Determining Distance to the GPS Satellites

215

Spread Spectrum Radio

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



216

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.

217

The Coarse Acquisition Code

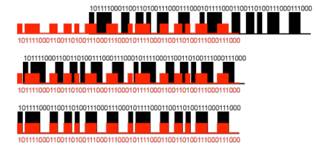

A short segment of PRN Code

- 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.

218

The Coarse Acquisition Code

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



219

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

220

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.

221

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.

222

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!

223

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.

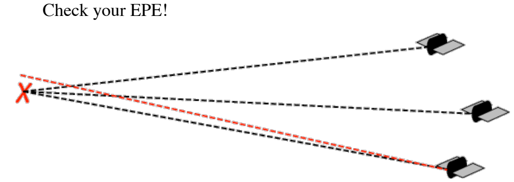
224

GPS Limitations – Poor satellite geometry

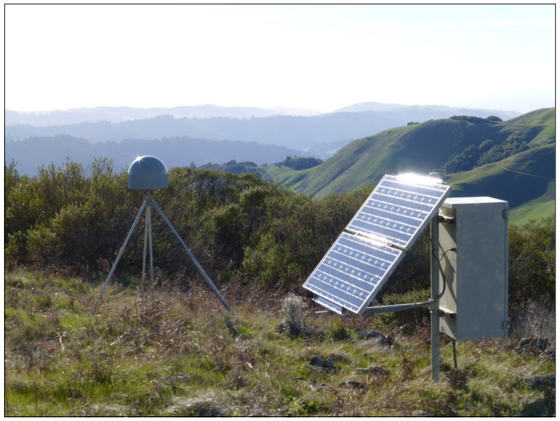
A small cluster of satellites can result in a large position error.

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

Check your EPE!



225



226

Emigrant Wilderness Orienteering Rally

227

Hints and Tips

- Plot the points quickly, before you join your maps together. Have someone else double check the point plotting.
- Consult the alternate maps. Don't write on them.
- Highlight trails, so they stand out visually.
- Mark your route next to the trail, not on top of it.
- Create course legs for off trail travel. Use your new route finding knowledge.
- Use the grid and contours for quick time estimates
- Create some choice points to skip checkpoints if time is short.
- Create a bailout plan.
  - Use the alternate maps to see the surrounding area.

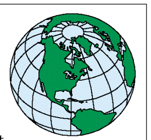
228

229

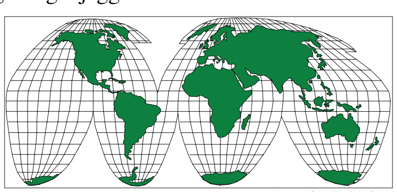
230

231

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?

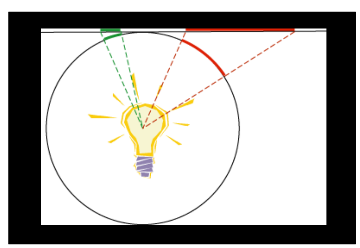


Interrupted Goode Homolosine Projection

232

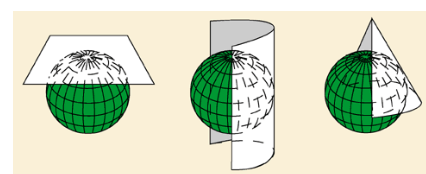
Map Projections

- A 2 dimensional example

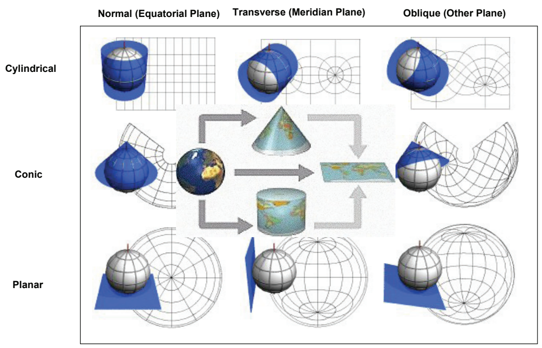


233

Basic Projection Types



234



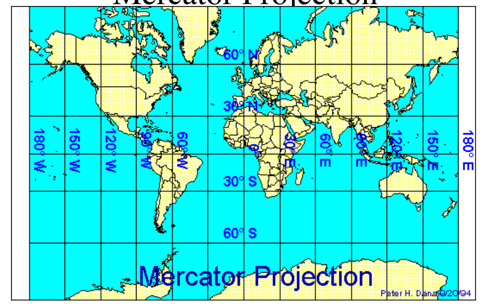
235

Distortion

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

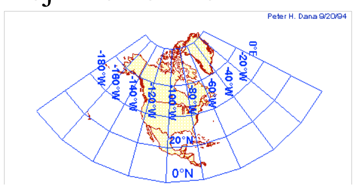
236

Mercator Projection



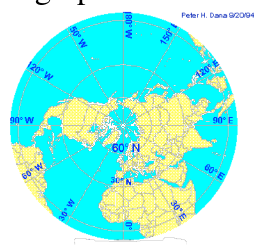
237

Lambert Conformal Conic Projection of North America

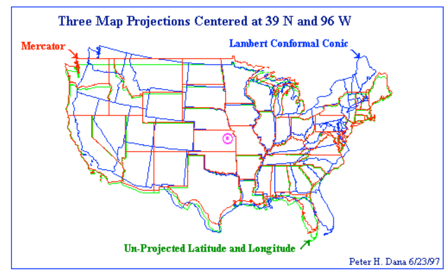


238

Stereographic - North Pole



239



240

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.

241

Which Map?

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

242

Geographic Names Information System

geonames.usgs.gov

243

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

Query Form For The United States And Its Territories

Please click the What's New tab for important information.

Feature Name: west valley college
Exact Match Exclude Variants
State or Territory: California
County:
Feature Class:
Topo Map Name (7.5'x7.5'):
Feature ID:
Elevation:
Feet Meters
BGN Decision Year:
Date Entered:
Check Map State: Select Map State

Click on the field name for help in entering query data.

Send Query Erase Query

244

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

245

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

246

Topo map sources

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

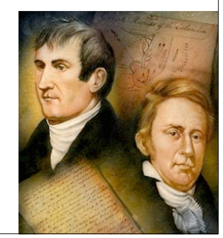
247

Public Land Survey System

248

"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



249

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

250

251

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"

252

Beginning Point of the
U.S. Public Land Survey

The Survey began in 1785.

253

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.

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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)

255

Principal Meridian

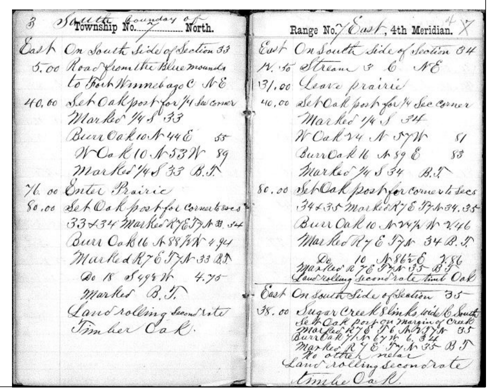
- True meridian that is astronomically determined and is extended from the initial point, north and south.
  - Monuments are placed at intervals of 40 chains (1/2 mile)

256

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

Section Line

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



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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

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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

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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.

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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.

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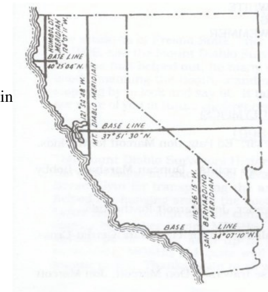
Initial Point

- 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.

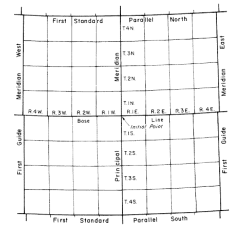
Initial Points for California & Nevada

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



Township and Ranges

- 6 miles square

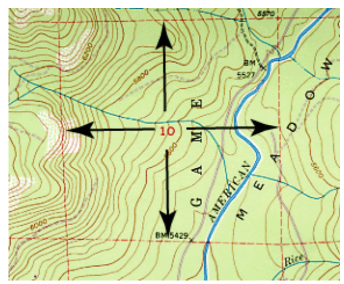


Sections

- 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

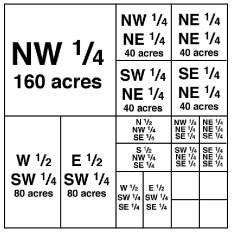
– Additionally, one could claim a quarter-section of land by "timber culture" (commonly called a "tree claim").

- 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



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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.

272

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"

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Plotting Lat/Lon Video

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Reading Lat/Lon Video

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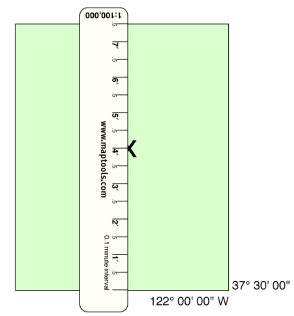
Measuring Latitude



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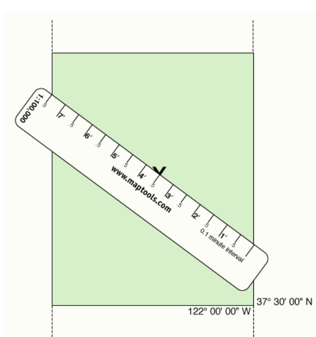
Measuring Longitude



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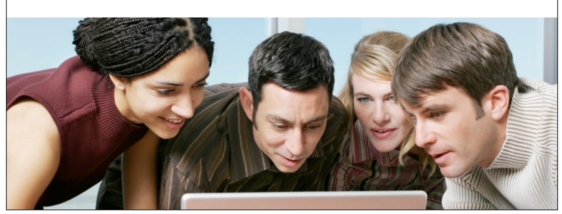
Lat/Lon Coordinate Exercise



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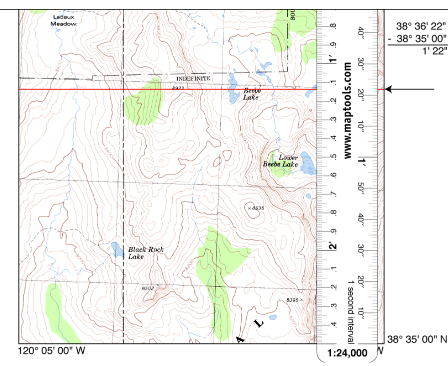

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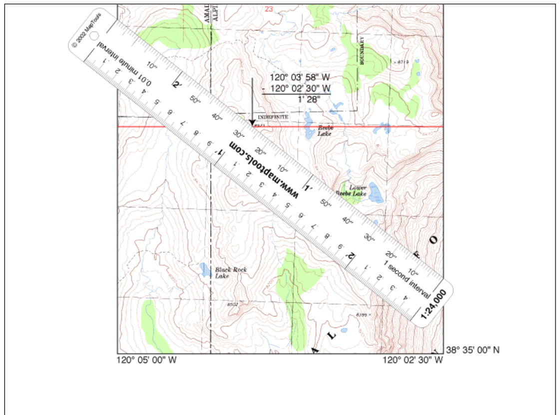

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Compass Bearing
Accuracy Challenge

282

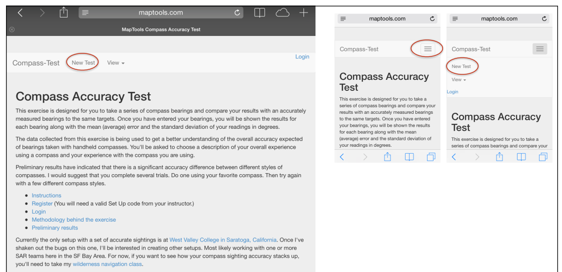
Align your sighting with the right edge of all targets, except **C.**

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

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

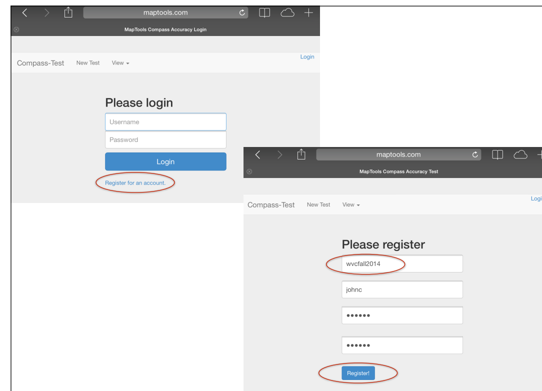
There are 18 targets to sight.

283



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

284



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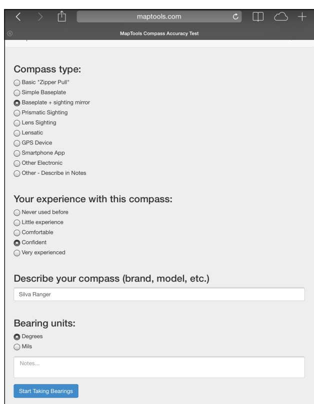

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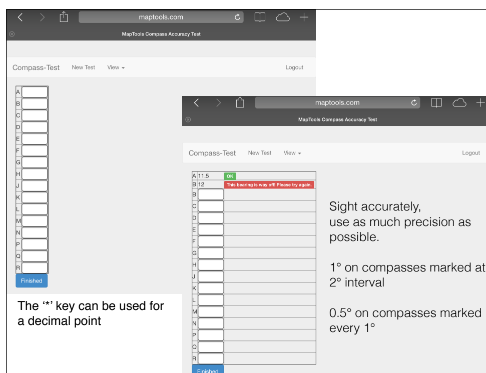

The '*' key can be used for a decimal point

Sight accurately, use as much precision as possible.

1° on compasses marked at 2° interval

0.5° on compasses marked every 1°

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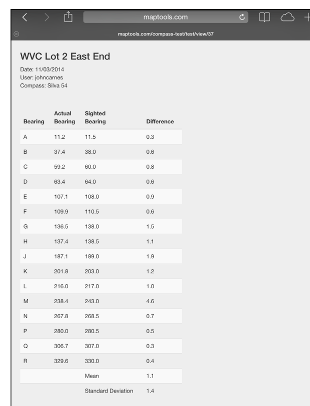
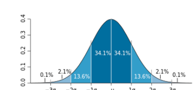


maptools.com/compass-test/test/view/37

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



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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

289

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°.

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Compass Test Sheet

Field Exercise

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

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

Triangulation Example

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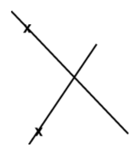
Location by Intersecting Back Bearings

- Two direction lines define a point.



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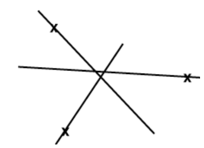
Location by Intersecting Back Bearings

- A third direction lines provides an error check.



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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.

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