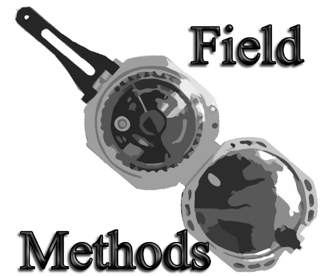
GEOLOGIC Field Methods



A field Geologist's Manual

by
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Introduction

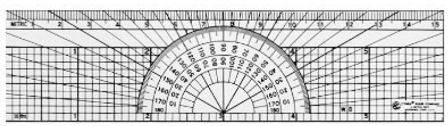
There is currently no good field work manual for budding geologists on the market. Most modern publication deal with a variety of equipment usually not accessible when geologists explore unknown territories. Field work instruments, while applicable for final planned surveys and data collection, have often little to do with the ingenuity and simplicity of procedures accessible to a good field geologist. This manual is therefore dedicate to the few things a geologist will have with him or her when doing routine geologic field work. The methods explored and presented in this publication are truly universally applicable for any preliminary field work project.

In this preliminary edition, many things are taken from other texts, many of them no longer in circulation. However, other contents are proprietary Dr.K material, not available anywhere else. This is especially true for the nomographs presented here for easy conversion and calculation.

Field Geologist Equipment and Materials Check-List

MANDATORY:

- ☐ Carrying Case / Backpack dedicated to field materials. May also hold personal items (Lunch, water, etc.)
- ☐ FIELD NOTEBOOK: high quality, water-resistant paper, waterproof covers, 4 ½" × 7 ¼", grid / graph + Wide rubber band to hold field notebook closed.
- ☐ Pencils (mechanical) & Colored Pencils, Sharpie™
- ☐ Short Ruler Protractor Ruler (6 in)



- ☐ Handlense, Acid Bottle
- ☐ Small Tape measure (~2m length)
- ☐ Light colored measuring rope ~¼" (~50m+)
- ☐ Clipboard with cover (9"+ wide, suitable for maps / airphotos)
- ☐ Heavy duty Ziplock™ bags (get the thickest ones you can) or better yet, cloth bags! + A few small sample bottles for small specimens
- ☐ Small index cards
- ☐ Pocket knife (Swiss Army style)
- ☐ Toilet paper or paper towels (to wrap specimens) ...and possibly other important business ☺
- ☐ Rock Hammer (Chisel point, NO carpenter's hammer)
- ☐ Brunton™ Compass

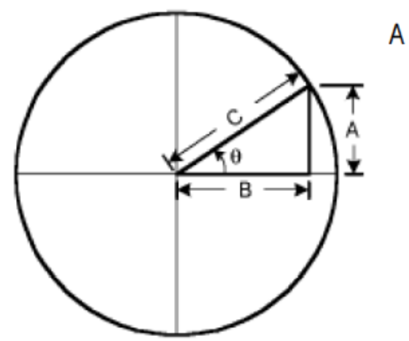
OPTIONAL:

- ☐ Rock/Mineral ID kit (Hardness, Density, Streak)
- ☐ Camera
- ☐ Pocket microscope
- ☐ Water bottle (for analysis)
- ☐ Chemical ID Kit (Micro torch, various acids, glass slides, etc.)
- ☐ Lighter
- ☐ Chisel
- ☐ Magnets (Keep those far away from your Brunton™, especially during

References and Conversions

Inches	Feet	mm	cm
1/8	0.0104	3.1750	.31750
1/4	0.0208	6.3500	.63500
3/8	0.0313	9.5250	.95250
1/2	0.0417	12.700	1.2700
5/8	0.0521	15.875	1.5875
3/4	0.0625	19.050	1.9050
7/8	0.0729	22.225	2.2225
1	0.0833	25.400	2.5400
2	0.1667	50.800	5.0800
3	0.2500	76.200	7.6200
4	0.3333	101.60	10.160
5	0.4167	127.00	12.700
6	0.5000	152.40	15.240
12	1.0000	304.80	30.480

Conversions	Conversions
1 inch = 2.54 centimeters	1 centimeter = 10 millimeters
1 foot = 12 inches	1 centimeter = 0.01 meters
1 foot = 0.305 meters	1 centimeter = 0.394 inches
1 yard = 3 feet	1 meter = 100 centimeters
1 yard = 0.914 meters	1 meter = 3.281 feet
1 chain = 66 feet	1 meter = 1.094 yards
1 mile = 5,280 feet	1 kilometer = 1,000 meters
1 mile = 80 chains	1 kilometer = 0.6214 miles
1 mile = 1.609 kilometers	1 hectare = 10,000 meters^2
1 acre = 43,500 feet^2	1 hectare = 2.471 acres
1 acre = 0.4047 hectares	



$SIN(\theta) = A/C$ $CSC(\theta) = C/A$

$COS(\theta) = B/C$ $SEC(\theta) = C/B$

$TAN(\theta) = A/B$ $COT(\theta) = B/A$

A = side opposite angle θ
B = side adjacent to angle θ
C is the hypotenuse

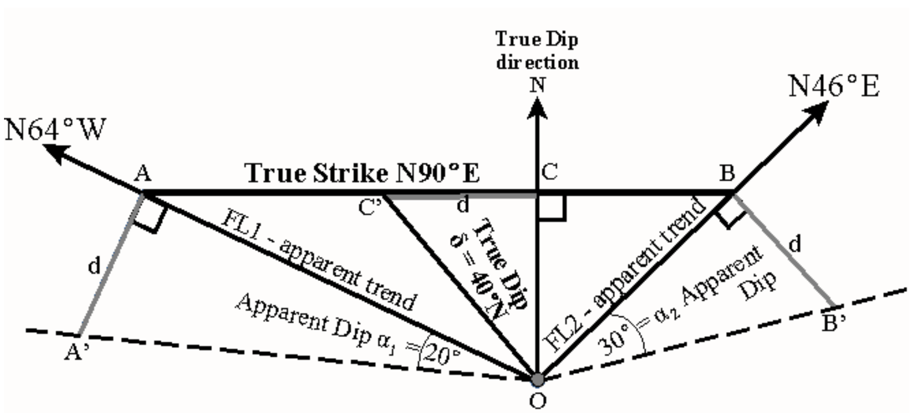
$$C^2 = A^2 + B^2$$

STRIKE and DIP - Apparent Dip and Direction (Graphical Solution)

Sometimes rock outcrops are too convoluted to get a good STRIKE and DIP reading directly. Here, arbitrary apparent dips and their bearing can be measured and true STRIKE and DIP can be solved.

<u>Example:</u> Two apparent dips of a plane (e.g., dike, vein) are measured in the field on two surfaces (e.g., joints). The first at 20° along the N64°W direction and the second at 30° along the N46°N direction. What is the true STRIKE and DIP of the plane?

1. Pick a point, O, at the center of your graph paper.
2. Draw the direction (bearing) of the apparent dips (i.e., N64°W and N46°E) from point O.
3. Call these FL1 and FL2, respectively.
4. Subtend apparent dip angle α_1 from FL1, and apparent dip angle α_2 from FL2.
5. Use a straight edge and choose an arbitrary depth d perpendicular to FL1.
6. Find point A where d intersects the trend of the apparent dip (i.e., the N64°W or FL1 line)
7. Use exactly the same d length for FL2, and repeat steps 5 and 6 for the second apparent dip, except that the intersection point is marked as B.
8. Connect A to B. This is the true STRIKE of the unit. Read bearing from North using a protractor.
9. Draw a perpendicular line to AB from point O. Find its intersection with the STRIKE line. Mark it point C. Line OC is the true DIP direction.
10. Measure the same d distance along AB from point C. Determine point C'.
11. Connect C' to O, and then read the angle between OC and OC' using a protractor. This is the true dip amount (δ = 40°).



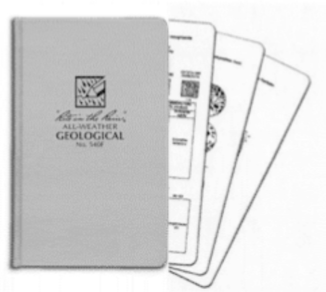
measurements)
- ☐ Calculator (Scientific, but cheap)
- ☐ Few strips of colored vinyl or colored electricians tape for marking

<u>CLOTHING & PERSONAL ITEMS:</u>

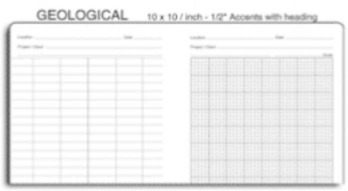
- ☐ Good hiking boots (Previously broken in)! Do not try to break in during field work.
- ☐ Several pairs of quality hiking socks
- ☐ Sun glasses that can double as safety goggles.
- ☐ Rain coat or poncho (small roll-up to carry in backpack)
- ☐ Hat and Beanie hat. You are often in full sun. High elevations may get sensitively cold, even in Summer.
- ☐ Sunscreen, sunblock.
- ☐ Gloves, for handling rough rocks and against cold.
- ☐ Drinking Water.
- ☐ First aid kit, especially band-aids.

Field Notes & Notebook

The field notebook must be high quality, water-resistant paper with waterproof covers. Standard size is 4 ½ × 7 ¼ in and should have grid or graph paper at least on every second page. Geological field notebooks are not cheap, but well worth it for they become a permanent record of your field surveys.



Taking good field notes is the most important practice a student can learn in geologic field work. Field notes should be clean and legible.

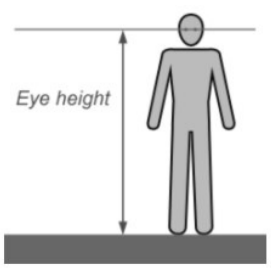
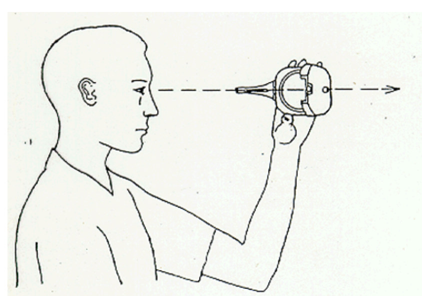


First Page Entry

The first page of your field notebook should contain the following information:

1. **Full contact information so lost books can be returned.**
2. **Your eye height, both US and metric units.**

To measure eye height:

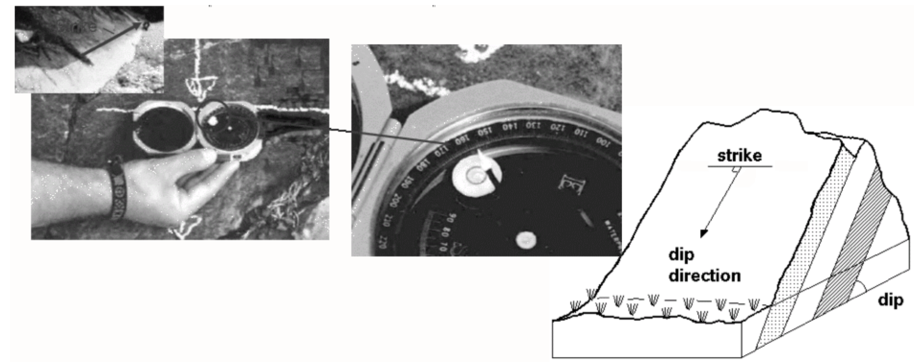
With Partner	Without Partner
Wear shoes you usually use for fieldwork. Stand straight and look straight ahead. Have a partner measure the distance from the floor to your eyes.	Wear shoes you usually use for fieldwork. In a room hold Brunton™ absolutely level and sight unto target at same level on a wall as indicated. Measure height from floor to target.
	

Formations: Measuring STRIKE and DIP

STRIKE: GEOGRAPHIC DIRECTION OR BEARING OF A LINE OF INTERSECTION BETWEEN A TILTED PLANE AND A HORIZONTAL PLANE.

Note: For measuring STRIKE only the *north-half* of the compass is used, regardless of which end of the needle points there. STRIKES would therefore be read as northeast or northwest, never southeast or southwest.

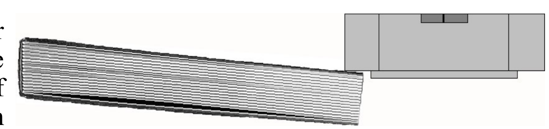
STRIKE and DIP - Direct Measurement



Measuring Strike directly is the best option.

1. Find a tilting bed. If slope is bumpy or uneven, use a ridged, flat object as underlayment, like your field notebook.
2. Open Brunton™ all the way and hold the straight side horizontally against the tilting bed as pictured. *SEE IMPORTANT NOTE BELOW
3. Leaving the straight side pressed against the slope, rotate and hinge the instrument slightly until the bulls eye bubble is exactly centered, making sure that the compass is flush to the tilted plane.
4. Read STRIKE as the bearing in the north-half of the compass and record in NE or NW quadrant notation.

Note: DIP is exactly 90 off-set to the STRIKE direction. It should always be measured with the STRIKE and recorded as degrees tilt with lettered tilt direction (NW or SW or SE or NE).



NOTE concerning step #2: For only slightly tilting beds, the Alidade Mount is in the way of leveling the bubble and getting an accurate reading (Yes, the Brunton™ has flaws) Use a thick ridged field notebook and use the edge of the book and of the Brunton™ to level the bubble as pictured. You can rotate the book around keeping it flat on the tilted outcrop.

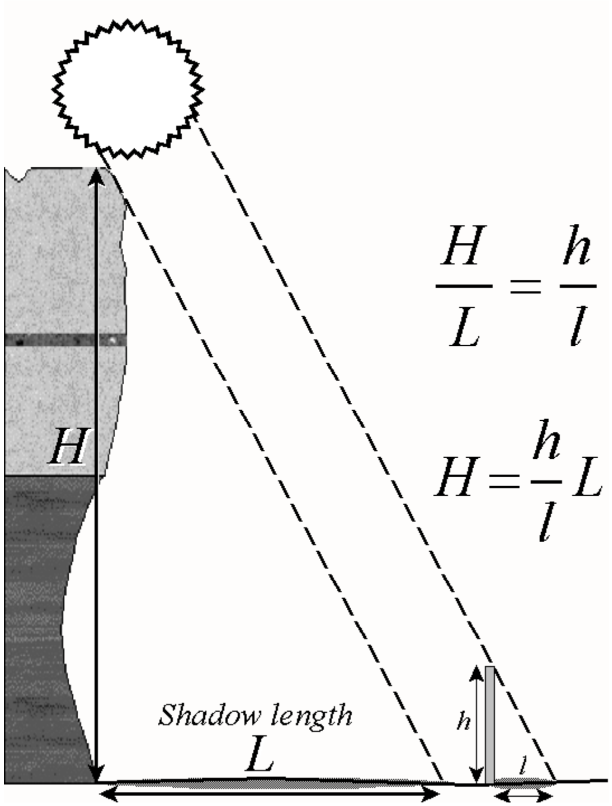
Method V - NO Brunton™, NO Problem: Height by Shadow & Stick

This method does NOT require a Brunton™ Transit. However, you must be able to pace to the target. ***Note: This works only on a sunny day when your tall outcrop casts a shadow toward you.***

1. Make sure that the outcrop you try to measure casts a shadow toward you.
2. Find a straight stick (A hiking pole works great) and put vertically into the ground.
3. Measure the length of the stick above ground (h).
4. Measure the length of the shadow the stick is casting (l).
5. Measure the length of the shadow the outcrop is casting (L).
6. The ratios of rise/run or height/shadow length for both objects are the same.

$$\frac{H}{L} = \frac{h}{l} \qquad H = \frac{h}{l} L$$

7. Solving this ratio for H gives you the height of your outcrop.



3. Pacing distance, both US and metric.

Normal Pace: Lay out a 50m distance with a tape. From the starting point walk the 50m at a normal gait (do NOT artificially stretch your step). Divide the number of steps needed to cover the laid out distance by 50. This is your single STEP in meters. Double STEP is called PACE and is recorded. Your PACE is very useful in measuring larger distances.

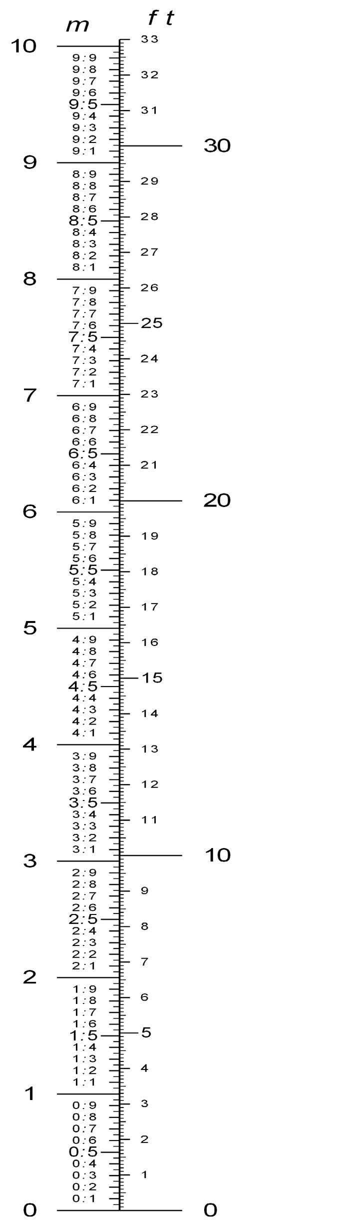
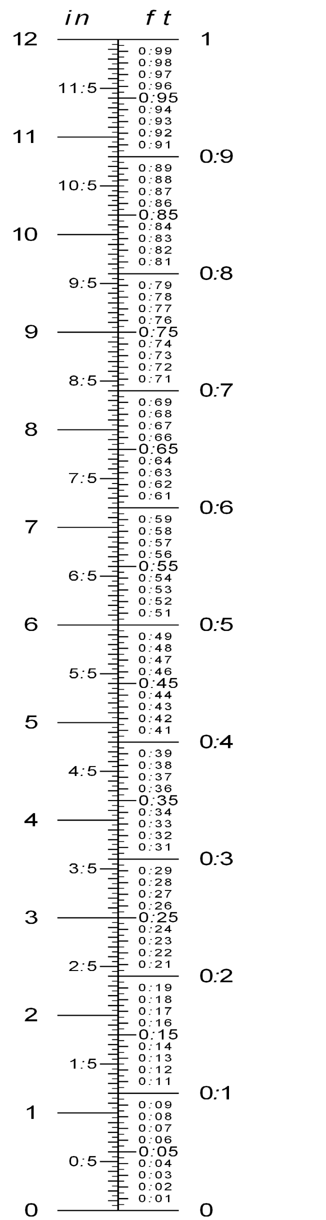
Uphill Pace: Principally you use the same method as above but going up a steep incline. Your natural gait will change. Again, do NOT artificially stretch your step. Your double step is recorded as your UPHILL PACE.

Downhill Pace: Reverting to the same methods already described, go down a steep incline in a natural gait while counting your steps. Again, do NOT artificially stretch your step. Your double step is recorded as your DOWNHILL PACE.

Having employed these methods, complete the following table and transfer these permanent results to the first page of your field notebook as well:

	m (decimal)	**ft (decimal)**	**ft (ft' in")**
Eye Height			
Normal Step			
Normal Pace			
Uphill Step			
Uphill Pace			
Downhill Step			
Downhill Pace			
Conversion factors:			
1m = 3.28084ft	1ft = 0.3048m	1ft = 12in	1in=0.0833333ft

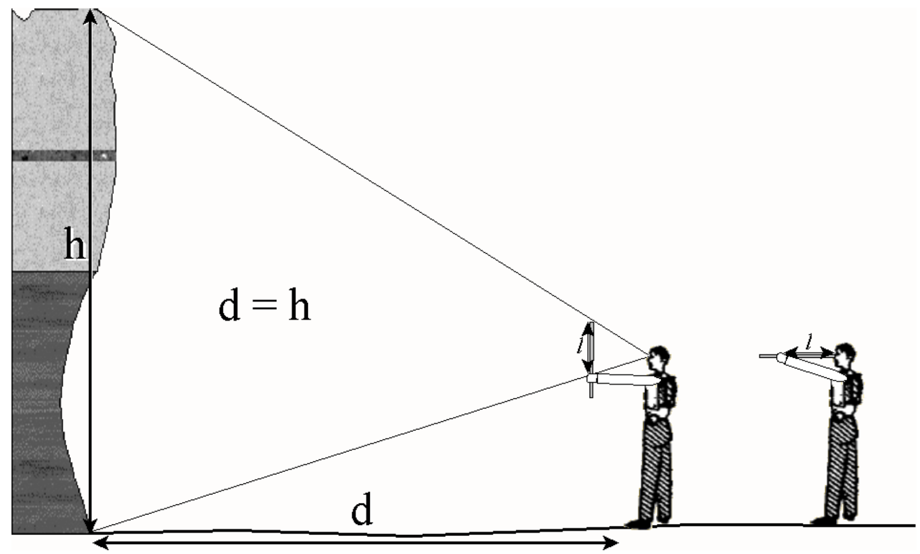
Conversion Nomographs

m to ft conversion	in to decimal ft conversion
	

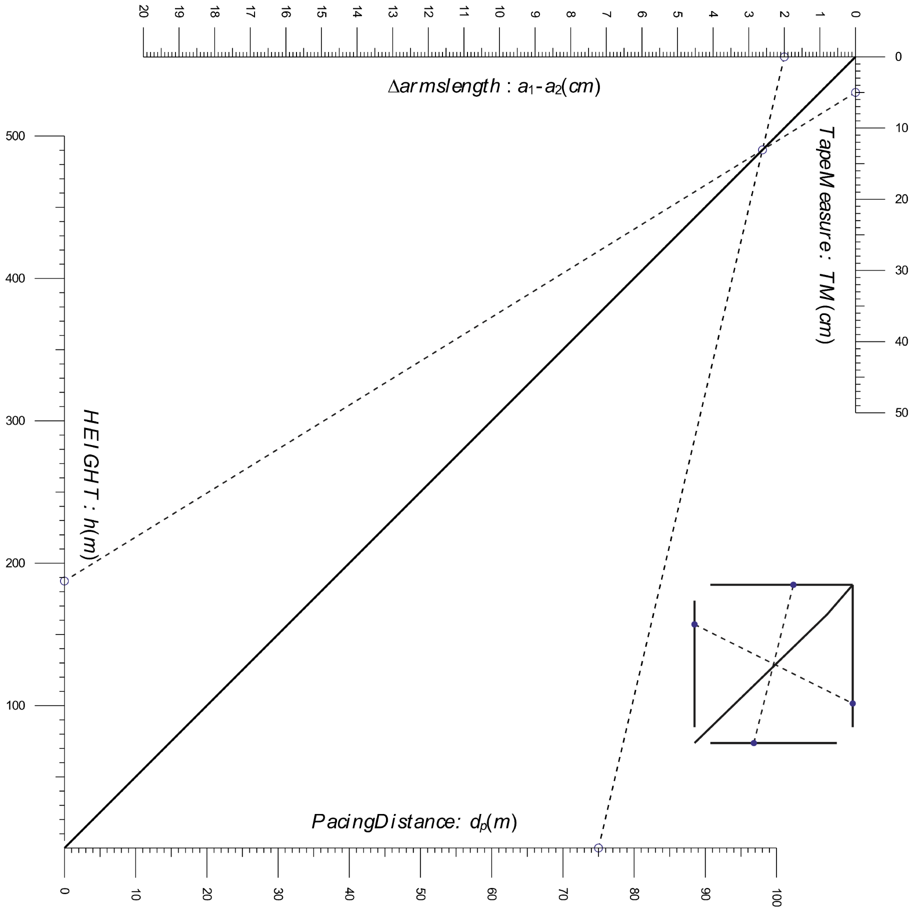
Method IV - NO Brunton™, NO Problem: Height by Stick

This method does NOT require a Brunton™ Transit. However, you must be able to pace the distance to target.

1. Find a long, straight stick, a little longer than the length of your arm.
2. Measure the distance from your cheek bone (don't poke your eye) to the joint of your thumb and index finger with arm is stretched out horizontally in front of you.
3. Next, hold the stick with your fist vertically at arm's length in front of you, making sure that the portion above your fist is the same as your measured cheek bone to hand distance.
4. Now walk toward or away from the object that you want to measure until the object's base appears to rest on top of your fist, while the top of the stick appears to touch the top of the object.
5. The pace or measured horizontal distance from that exact point to the base of your object is equal to the height of the object.



Nomograph for Height using the Parallax Method



Parallax height: $h = d_p \times TM \;/\; (a_1 - a_2)$

Parallax Height Nomograph Example:

1. Plot a_1 - a_2 difference on top horizontal axis (e.g. 2.0cm) and paced distance (d_p) on bottom horizontal axis (e.g. 75m).
2. Connect plots and mark where line intersects the SW to NE diagonal of the nomograph.
3. Plot your exact tape measure height on right hand vertical scale (e.g. 5.0cm).
4. Connect tape measure plot with diagonal intersect mark and extend to left hand vertical scale.
5. Read height of object from left vertical scale (e.g. 188m)

Taking Field Notes

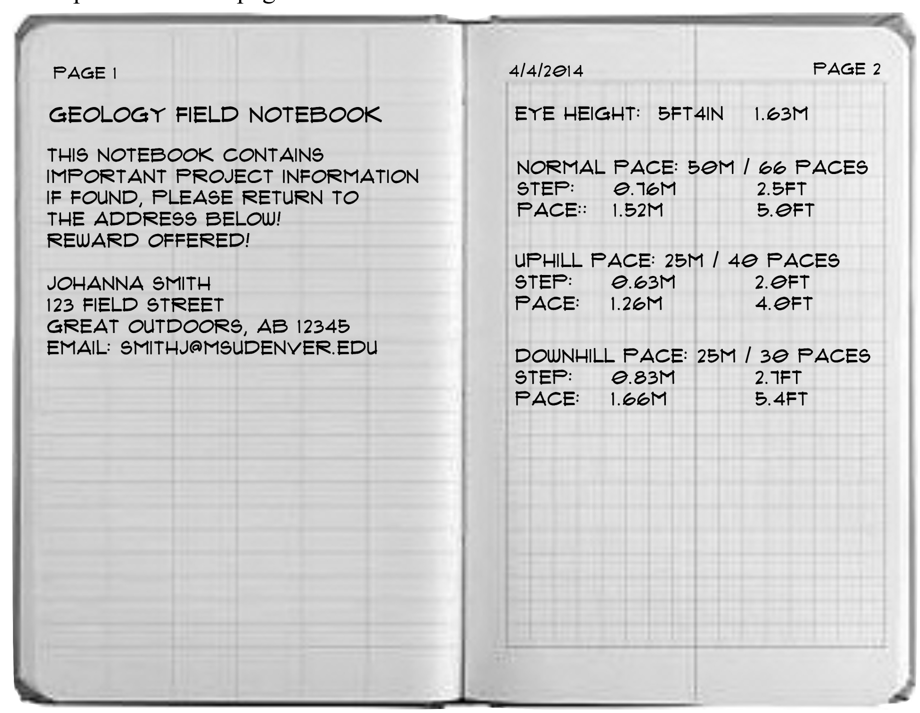
The field notebook is used to record field information for future reference. The become a permanent record of your activities. Unlike lecture notes, field notes are often assessed, and when working commercially may become company rather than individual property. For that reason they have to be legible and comprehensible to others.

- ☐ Field Notes are taken when the work is done. Not afterwards in the office.
- ☐ They have good structure with clear text and illustrations.
- ☐ All measurement and calculations are written out.
- ☐ Do NOT use cursive handwriting! Lettering (print) is required. For best results, use all UPPERCASE letters like in architectural drawings.
- ☐ Date and page number each page for later reference.

Common lettering for architectural or technical drawing:

abcdefghijklmnopqrstuvwxyz 1234567890

Example of first two pages field note entries:



Notebook Entries

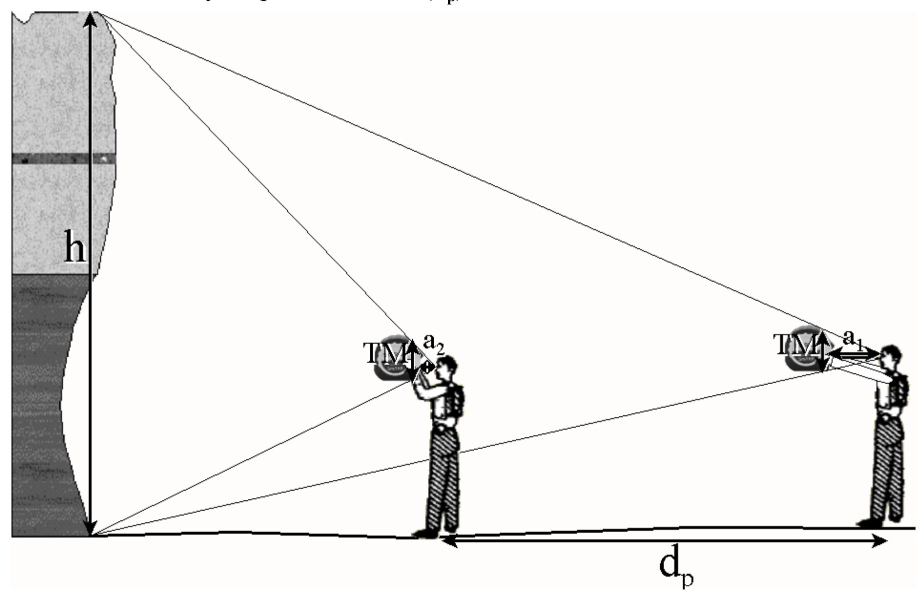
It is ok to use shorthand and abbreviations. Full sentences are not required. Remember that a geologist college reading your field notes should be able to decipher your shorthand. Here are some common terms:

above	abv	crystal	Xl	matrix	mtx
abundant	abnt	dark	dk	metamorphic	met
acicular	acic	dense	dns	metasomatic	msm
albite	Ab	detrital	dtrl	mica -eous	mica
altered	alt	dolomite	Dol	minor	mnr
amount	amt	effervescence	effv	muscovite	Musc
amorphous	amor	elongate	elg	numerous	num
amphibole	Am	euhedral	euhed	occasional	occ
andalusite	And	fault -ed	flt	odor	od
andesite	Ands	fill -ed	fl	orthoclase	Orth
angle	∠	fissile	fis	overgrowth	ovgth
anhedral	anhed	foliated	fol	pegmatite	Pgm
anhydrite	Anh	foraminifera	Foram	plagioclase	Plag
anorthite	An	formation	Fm	porous -ity	por
arkose -ic	ark	fracture -d	frac	porphyry	prphy
at	@	fragment -ed	frag	prominent	prom
augite	Aug	gabbro	Gbr	pyrite	Py
average	avg	gneiss	Gns	quartz	Qtz, Qz
band -ed	bnd	grade -d	grd	rhyolite	Rhy
bed	bd	grading	grdg	rocks	Rx
bedded	bdd	grain -ed	gr	rounded	rnd
bedding	bdg	granite	Gr	sandstone	Ss
between	b/w	granodiorite	Grd	sedimentary	sed
black	blk	granular	gran	shale	Sh
blocky	blky	gray	gy	siliceous	silc
blue -ish	bl	greater	>	siltstone	Sltst
brachiopod	brach	green	gn	smaller	<
brittle	brit	gypsum	Gyp	soluble	sol
brown	brn	hard -ness	hd	unconformity	uncnf
calcareous	calc	hematite	hem	volcanic	volc
carbonate	carb	horizontal	hrztl	with	w
cement -ed	cmt	hornblende	Hbl	without	w/o
chert	Cht	igneous	ign	xenolith	Xen
cherty	chty	interbedded	intbd		
clastic	cl	intrusion	intr	Add your own:	
clay -ey	cly	joint	jnt		
claystone	Clyst	kaolinite -ic	Kao		
common	com	laminated	lam		
conchoidal	conch	leached	lchd		
conglomerate	Cgl	limestone	Ls		
contact	ctc	limonite -ic	lmn		
crossbed	xbd	marly	mrly		

Method III - NO Brunton™, NO Problem: Height by Parallax

This method does NOT require a Brunton™ Transit NOR prior knowledge of the distance to the target. It is best to use the metric system for this method.

1. You will need a small tape measure with a mm, cm, or m scale, as well as your pacing or step distance. A surveyors rope or tape is recommended.
2. Measure the exact height of the tape measure body (**TM**). *Note: Tape measure size in figure grossly exaggerated!*
3. Facing the object hold tape measure body vertically while extending the tape to your face touching your cheek bone.
4. Look through one eye and move tape measure body toward or away from you until height of the tape measure covers the height of the object in the distance exactly. Record the distance from cheek bone to tape measure body as $\mathbf{a_1}$.
5. Pace a significant distance toward object. Then repeat steps 3. and 4. Record the distance from cheek bone to tape measure body at the new position as $\mathbf{a_2}$ and note your paced distance ($\mathbf{d_p}$).

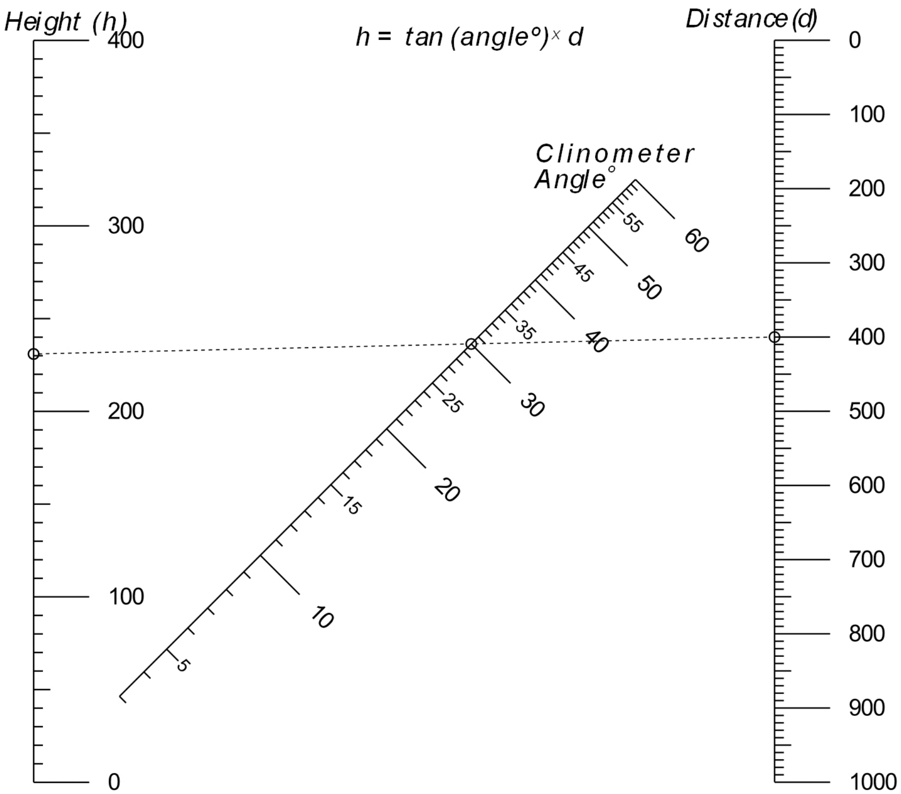


6. The height of the distant object can now be calculated as:

$$h = \frac{d_p \times TM}{(a_1 - a_2)}$$

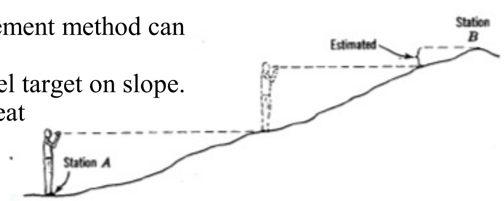
7. Watch units for calculation. You may also use the following nomograph for simplicity.

Nomograph for Height using Distance and Clinometer Angle



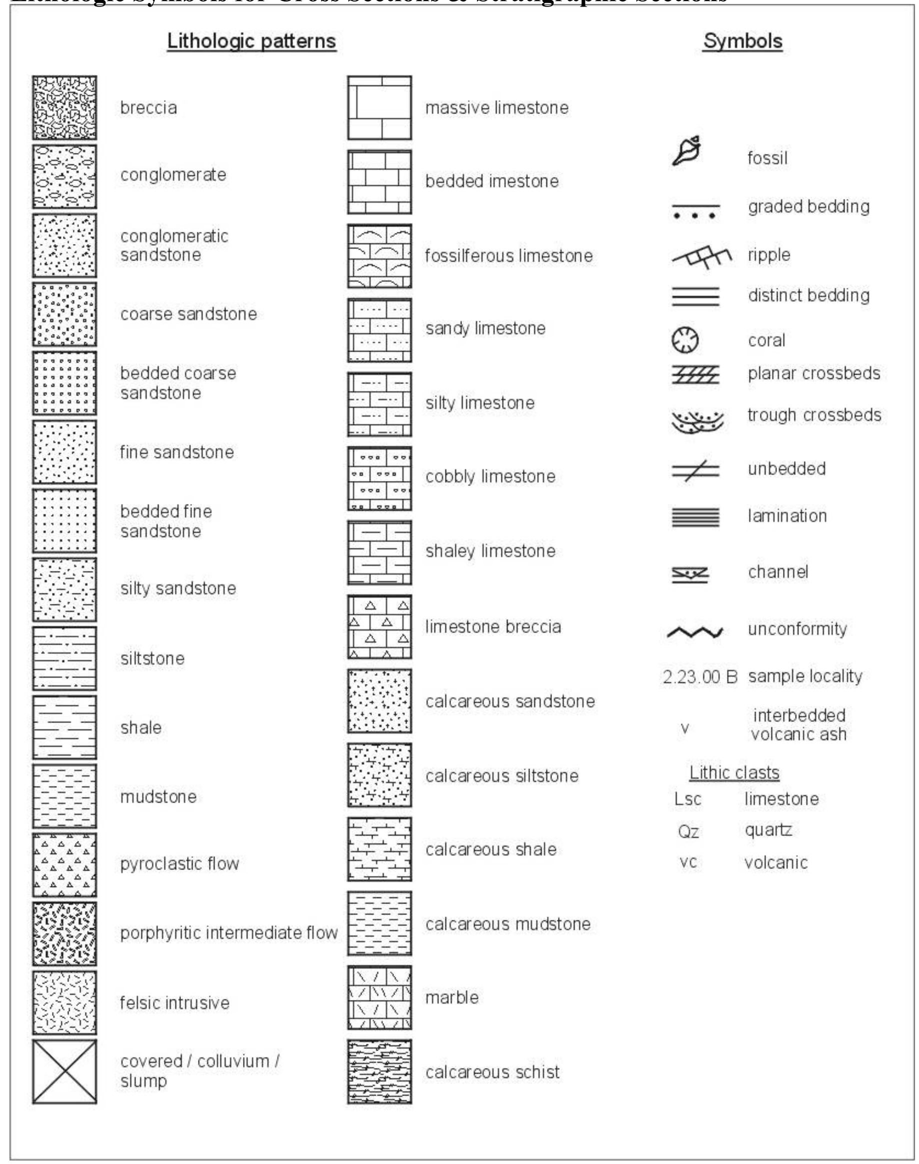
Method II - Height of Sloping Hills if **d** is NOT known

In sloping terrain, the eye-height increment method can be employed. As depicted:



1. Start a point A and shoot level target on slope.
2. Pace to target and repeat process until arriving at top of hill.
3. Last segment may need to be estimated as shown.
4. When pacing distance and slope can be established, true distance can be ascertained and height can be calculated using the tangent height method.

Lithologic Symbols for Cross Sections & Stratigraphic Sections



Use lithologic patterns to illustrate stratigraphic sections and geologic map sketches.

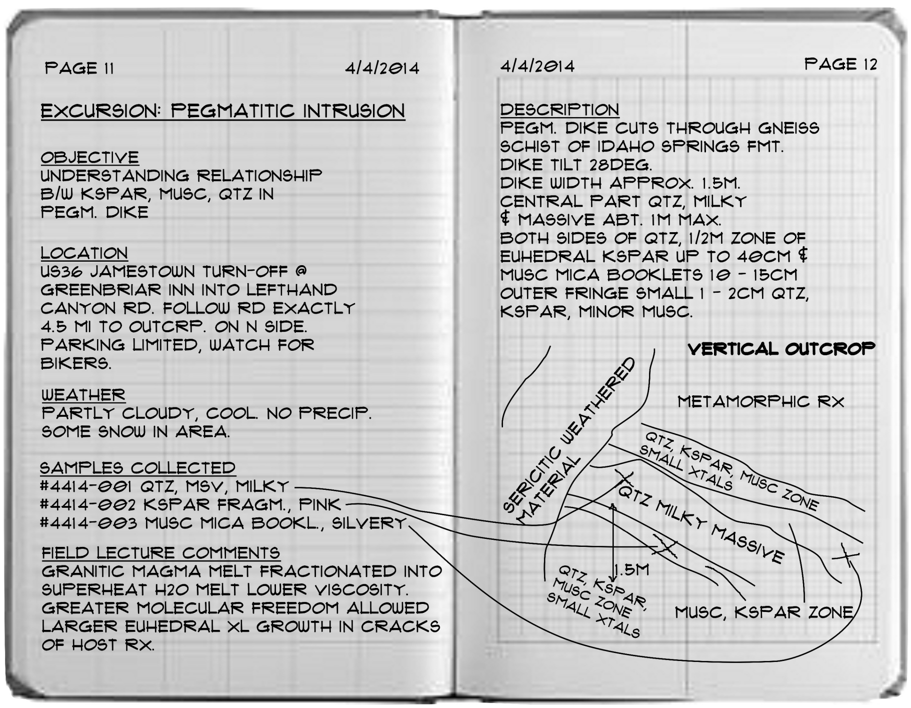
Sketching

Sketching is one of the most important skills that a geologist can develop. Sketches generally capture geometry and field relationships better than photographs because they accentuate the most important details and are not encumbered by bad lighting and shadows. Sketching forces you to relate intimately to the detail of an outcrop and confront confounding relationships. You can and should sketch outcrops, contact relationships, locations, topographic features not clearly shown on map, structural features, fossils, etc...

When to sketch? If the written description of a geologic feature would take more time and notebook space than would be required for a sketch, then SKETCH IT! A picture is worth a thousand words' was never truer than in geological field work.

Sketching Rules:

- ☐ Show scale on the sketch and draw accordingly. If not drawn to scale then indicate.
- ☐ Title your sketch and indicate type of sketch, e.g. map, outcrop, etc.
- ☐ Sketches should be large, open and clear. Don't crowd.
- ☐ Transfer measurements as accurately as possible to your sketch such as angles/azimuths.
- ☐ Start with a simple outline. Then fill in details to scale.

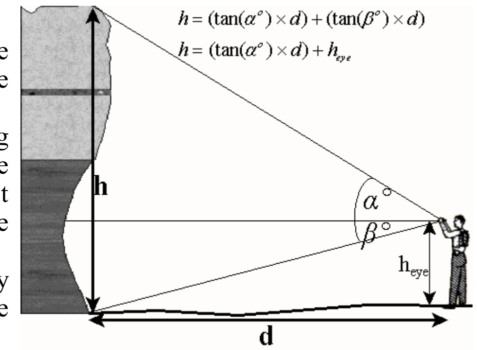


Measuring Height

Whenever possible measure height or formation thickness directly. However, these measurements on a vertical cliff can be challenging and/or dangerous. If **d** (distance) to the cliff or object is known, the following methods can be employed:

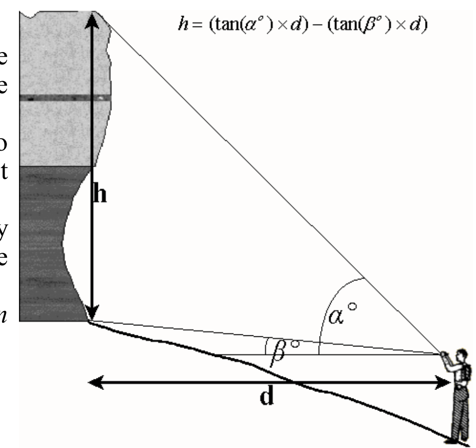
Method Ia - Height Measurement with Clinometer on Level / Downslope Ground

1. Obtain distance "d" to object.
2. From a level position measure angle to top of object (α°). (see figure)
   a. On downward sloping ground also measure angle (β°) to foot (bottom) of object. (see figure)
3. Calculate height "h" of object by the following equations or use nomograph.
   a. $h = (\tan(\alpha°) \times d) + (\tan(\beta°) \times d)$
   b. $h = (\tan(\alpha°) \times d) + h_{eye}$



Method Ib - Height Measurement with Clinometer on Upward Sloping Ground

1. Obtain distance "d" to object.
2. From a level position measure angle to top of object (α°). (see figure)
3. From a level position also measure angle (β°) to foot (bottom) of object. (see figure)
4. Calculate height "h" of object by the following equations or use nomograph.
   a. $h = (\tan(\alpha°) \times d) - (\tan(\beta°) \times d)$

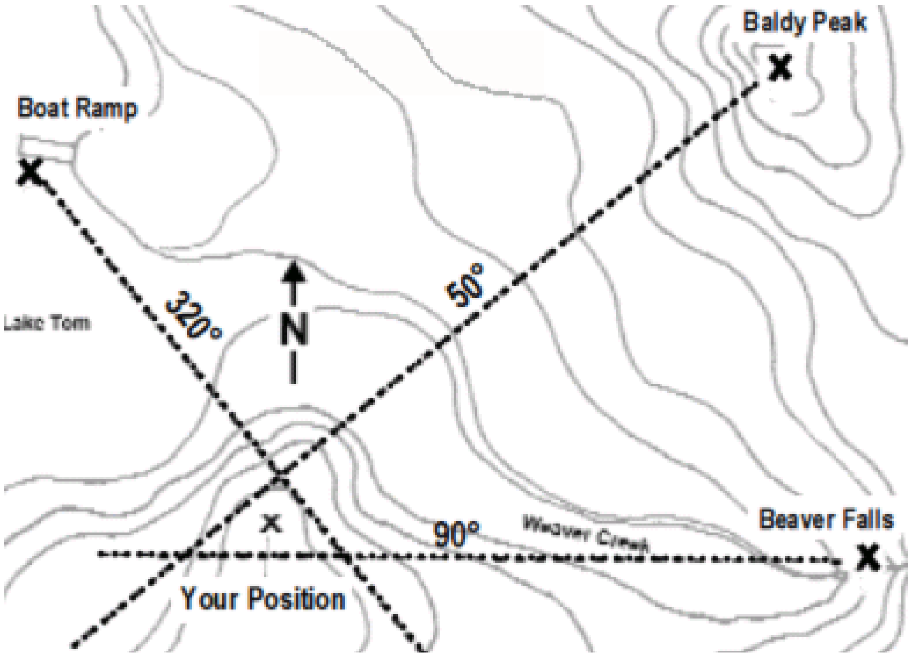


<u>Where in the World am I? - Finding your position using triangulation.</u>

This method used to find your approximate position, using a compass and a map. It can also be used to plot a course without a base map.

<u>Note:</u> Make sure the pocket transit is adjusted for the correct magnetic declination.

1. Identify three landmarks in the field, that are easily identified in the distance.
   a. When using a topomap, landmarks should be identified on map.
   b. Preferably landmarks should be over 50° apart.
2. Sight azimuth to each land mark and document.
3. Draw azimuth line on map or base map for each azimuth (see figure).



4. Your position is within the small triangle, or position formed by the intersection of the three lines. (See fig.)

Numerical Values & Calculations

Record of all measurements (angles, distances, strikes/dips, etc...) made in the field.

<u>Rules:</u>

- ☐ Write carefully. Words can be guessed at, numbers can NOT.
- ☐ Make numbers large and unambiguous.
  This is a real problem. Which one is the "zero"? 0 o °
  Lettering is therefore critical to distinguish "one" from "seven" (1 7 or 7) or "zero" from "oh". (0 o) Best to place a line through the "zero" as shown!
- ☐ Never write one number on top of another or try to change one number into another. Either erase completely or cross out incorrect numbers. Write corrected values either above, below or adjacent to the crossed out digit.
- ☐ If your numbers have a unit, ALWAYS write the unit behind the number. In general, *<u>a number without a unit is useless</u>*!

<u>Calculations & Equations:</u>

- ☐ Equations should contain explanation of symbols used.
- ☐ A reader should be able to follow where your values or numbers come from. Indicate accordingly.
- ☐ WRITE DOWN UNITS!!!!
- ☐ Show equations used before indicating any computation

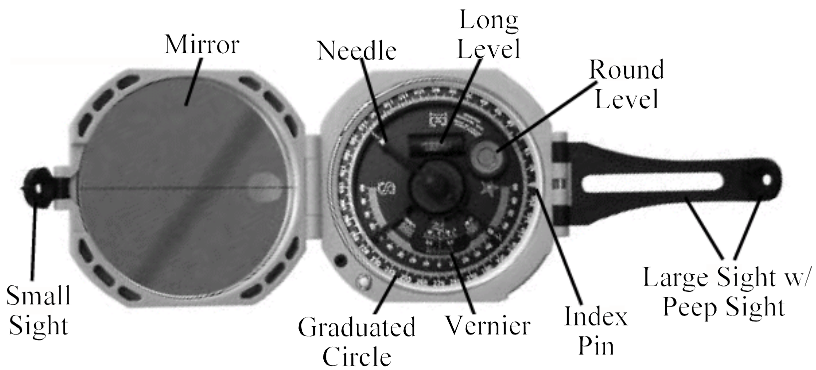
ACCEPTABLE EXAMPLE: $SG = \frac{Wa}{(Wa - Ww) \times 1.0 \, cm^3/g} = \frac{5.4g}{(5.4g - 3.5g) \times 1.0 \, cm^3/g} = 2.8 \, g/cm^3$

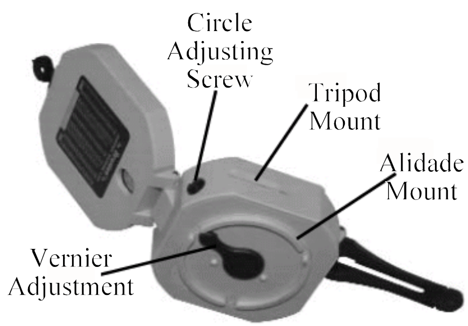
where W_a is mass in g of xl in air, W_w is mass in gms of xl in H2O determ. w/ 10-0.1g Pen Scale (Density Field Kit). SG = specific gravity in g/cm^3 .

UNACCEPTABLE EXAMPLE: ***answer is 2.8. obtained by dividing the measurements by the difference.***

The Brunton™ Compass

Overview, Parts and Pieces.

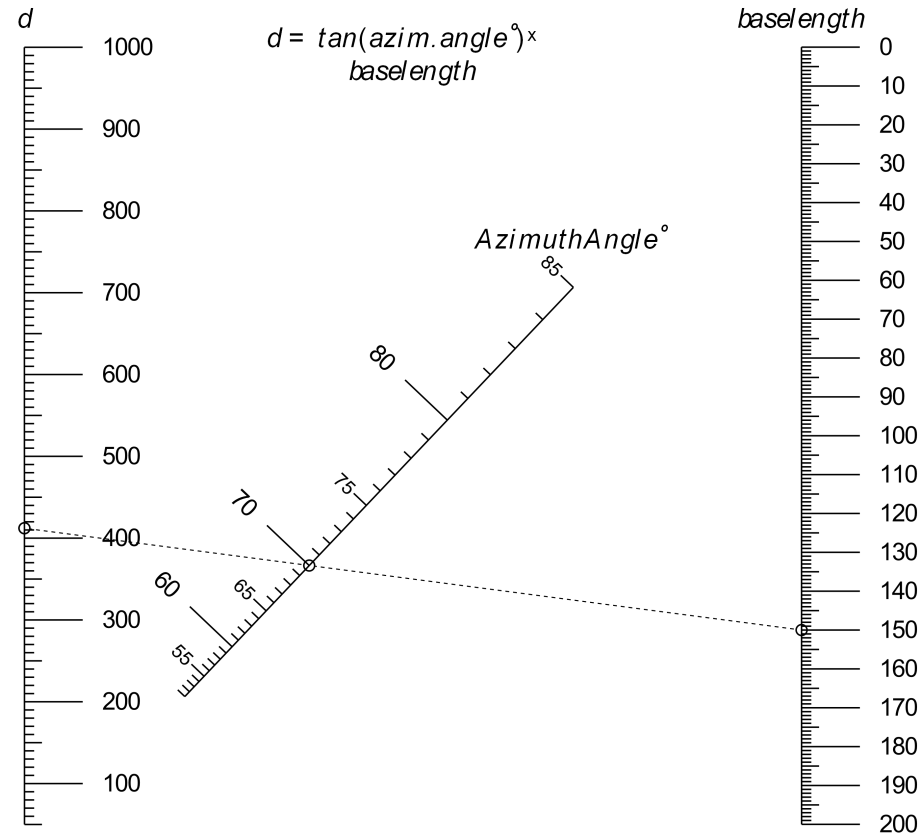




The Brunton™ Pocket Transit is not just a compass. It combines a surveyor's compass, prismatic compass, clinometer, hand level and a plumb into a single instrument. Use the Brunton Pocket Transit to measure azimuth (compass bearing), vertical angles, inclination of objects, percent grade, slopes, height of objects and for leveling.

Because the pocket transit is a direct reading compass, East and West are switched on the dial. This way you can read azimuth directly where the needle points on the graduated circle without transposing.

Nomograph for Distances using Base Length and Azimuth Angle

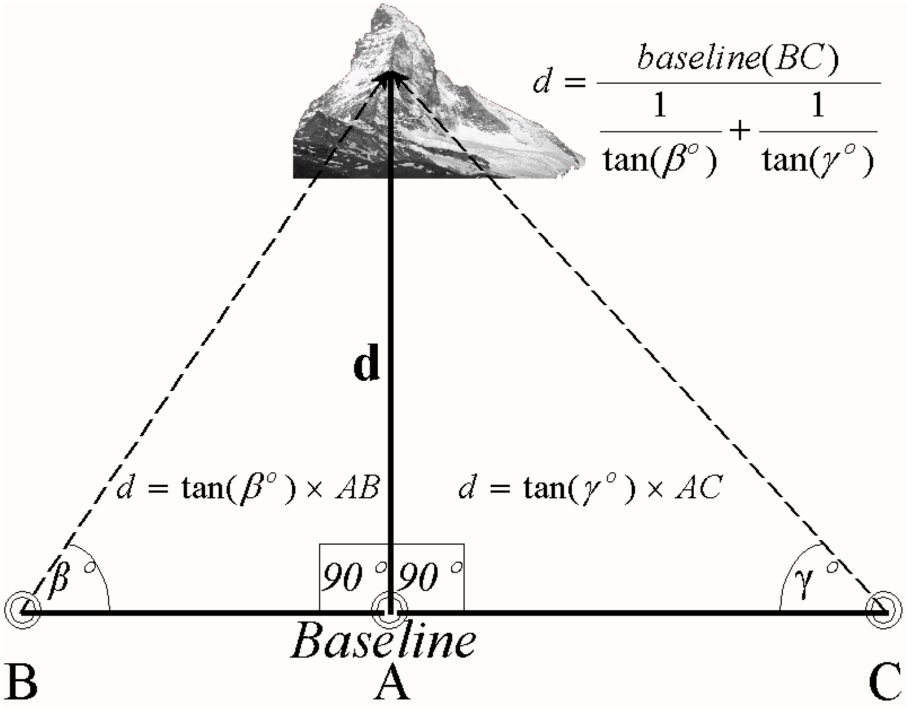


Note: The smaller the azimuth angle, the smaller the error. An azimuth angle of ±1 ° reading error will yield a ±3.6% error in **d** *at 51 ° and a ±21% error at 85 °provided that the paced base length is accurate. To decrease azimuth angle, increase paced base length if possible.*

Method II: True Distance by Double Triangulation

Sometimes objects are too far away or there are obstacles in your pace path to measure distances directly. In this case triangulation methods can be used to determine distances.

Warning: Precise measurement of azimuth angles are necessary to yield usable results.



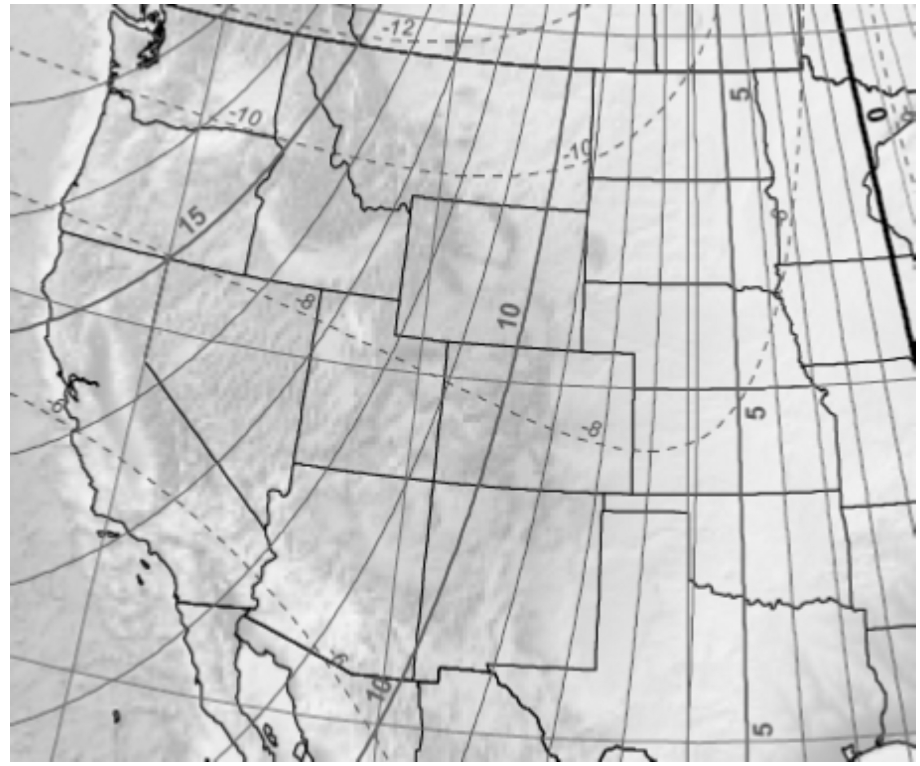
1. Find a point on an object to which you would like to determine the distance.
2. Brightly mark the spot on the ground where you are standing (Location A; see fig.) And get an exact azimuth bearing from A to the distant point.
3. Add 90°to this bearing and pace / measure a predetermined length from A to location C (see fig). Record paced or measured base length AC.
4. Measure and record azimuth angle γ° at location C.
5. Return to point A and subtract 90°from your first original bearing. Then repeat steps 3. and 4. for base length AB and azimuth angle β°(see fig.).
6. Distance ***d*** can now be calculated using one or all three of the equations given in the figure above.

- To mitigate errors and increase precision it is suggested to take an average for ***d*** calculated with all three methods.
- The following nomograph may also be used to determine ***d***.

Calibrating the compass, adjusting magnetic declination.

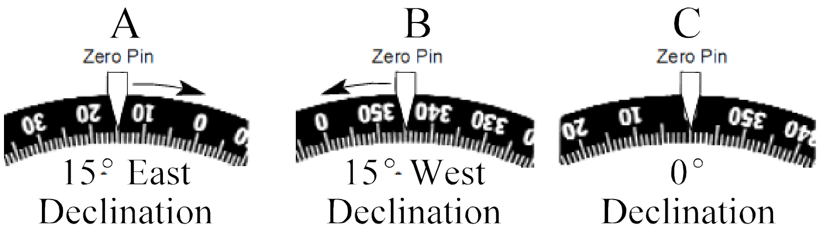
Magnetic North may deviate from the geographic North. This deviation is called magnetic declination and is expressed as the angular difference between true North and magnetic North. This declination can be east, west or even 0°, from your current position. At 0° declination, true north and magnetic north are aligned.

Current magnetic declinations for various locations of interest in the US can be read from an isogonic chart or declination map as in the following excerpt published by NOAA - National Geophysical Data Center.



Solid isogens west of the bold black “0" line show East (positive) magnetic declinations. Dashed grey lines show expected annual change in magnetic declination expressed in arc minutes. From World Magnetic Model (WMM2010).

To adjust your Brunton™ for magnetic declination, rotate the graduated circle by turning the circle adjusting screw. Begin with the zero pin at 0°. For East declination, rotate graduated circle clockwise from the zero pin. (Fig A) For West declination, rotate graduated circle counterclockwise. (Fig B) If magnetic declination is 0°, no adjustment is necessary. (Fig C)

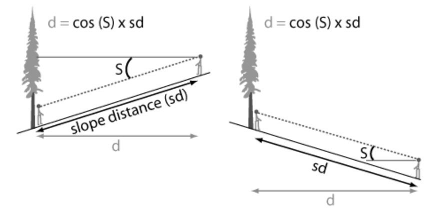


According to the isogen map, set your Brunton™ to 9° East for work in the Colorado Front Range, 10° East for Colorado's Central Rockies and 11° or 12° E when working in greater Utah. This means that in the greater Western US the 0° mark (True North) is to the right of the "zero pin"!

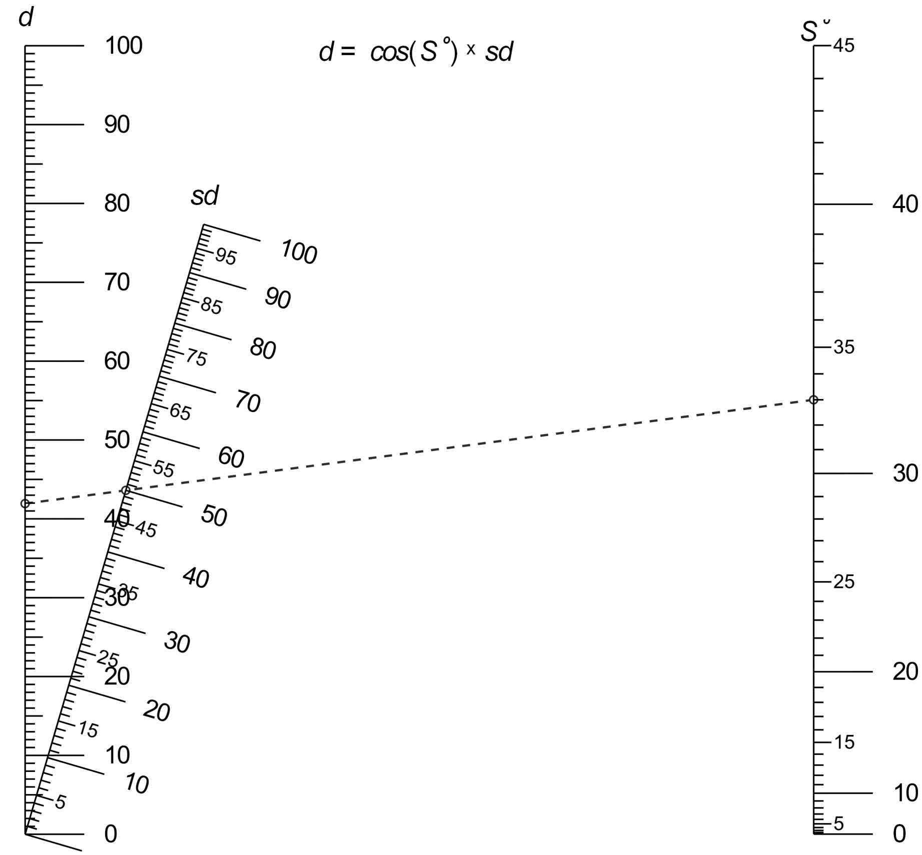
<u>Horizontal Distance Measurements (other than straight pace or tape)</u>

<u>Method I: True Distance by Uphill / Downhill Pace & Slope Measurement</u>

Using the PACE or STEP method to estimate horizontal distances should be no problem. However, your horizontal distance traveled will be unequal to your PACE distance when traveling up or down a slope. Therefore your paced distance must be compensated when in a hilly terrain. Slopes less than 5° do NOT need to be corrected.

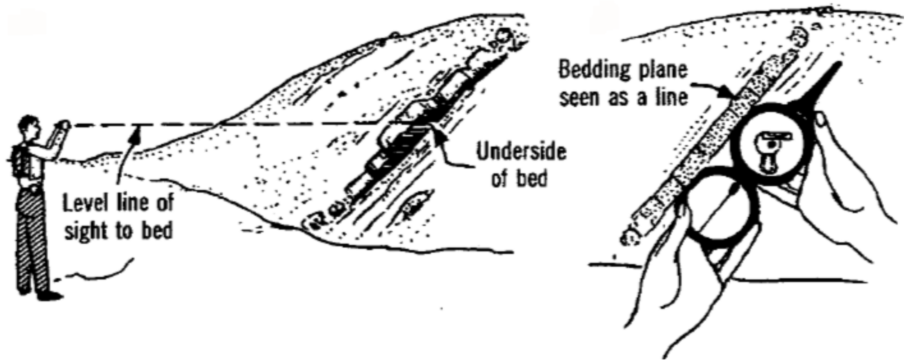


6. Take a slope measurement (S°)
7. Pace your uphill or downhill distance = slope distance (sd)
8. Calculate actual distance (d) or use nomograph below



Method 3 - Incline by Eye Sight (Side View)

Another method of examining the dip of rock strata is to stand at an exact view to a pronounced dipping bed.



1. Unfold Brunton™ completely.
2. Stand in line with the STRIKE of a tilted bed so you have an exact side view of the inclined strata.
3. Level your line of sight to a pronounced bed as indicated in the figure.
4. Adjust vernier until bubble in long level is centered.
5. Read inclination as previously explained.

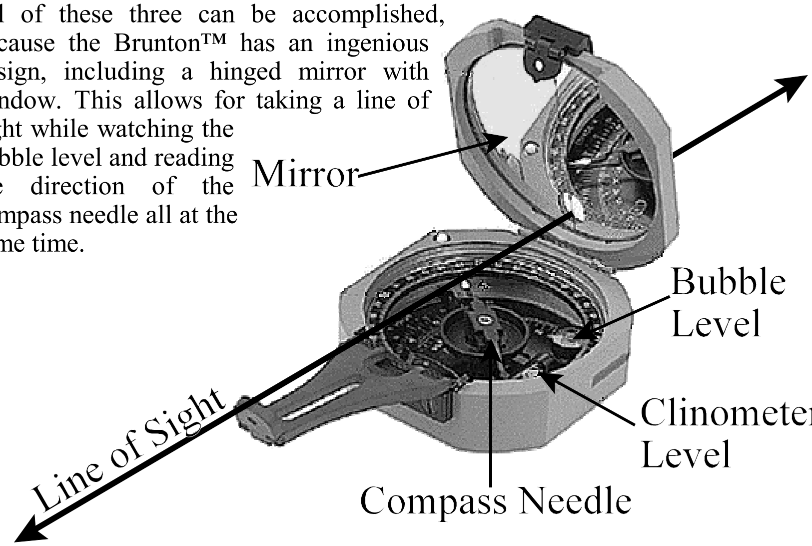
This method is not as precise as direct measurements and should only be employed if no other options are available.

Using the Brunton™ Pocket Transit

While many things can be done with the compass, the basics include measuring accurate direction and measuring accurate slopes or dip angles. In order to do any of these, you must be able to do the following 3 things simultaneously:

1. **DIRECTIONAL AIMING OR SIGHTING**
2. **HOLDING THE COMPASS ABSOLUTELY LEVEL**
3. **TAKING AN ACCURATE READING**

All of these three can be accomplished, because the Brunton™ has an ingenious design, including a hinged mirror with window. This allows for taking a line of sight while watching the bubble level and reading the direction of the compass needle all at the same time.



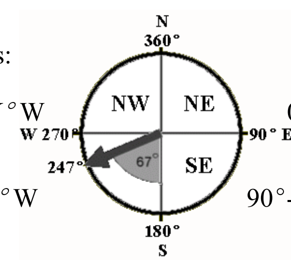
Reading Azimuth Scales

There are two types of Brunton™ Transits, those with a 360° azimuth scale and those with 4 section quadrants (4× 90°). For geologic field work, the quadrant type compass is preferred. If you do NOT have a quadrant system, you must convert your 360° readings into quadrants.

360° to Quadrant Conversions:

270°-360°= N *360°-X°* W

0°-90° = N *X°-0°* E



180°-270°= S *X°-180°* W

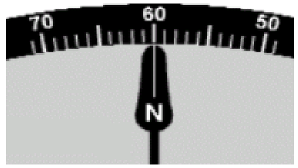
90°-180°= S *180°-X°* E

Azimuth Measurements

There are three methods of taking a bearing or measuring your azimuth using the Brunton™ transit. All require for the compass to be held absolutely level as indicated by the bubble or bulls eye level on the instrument.

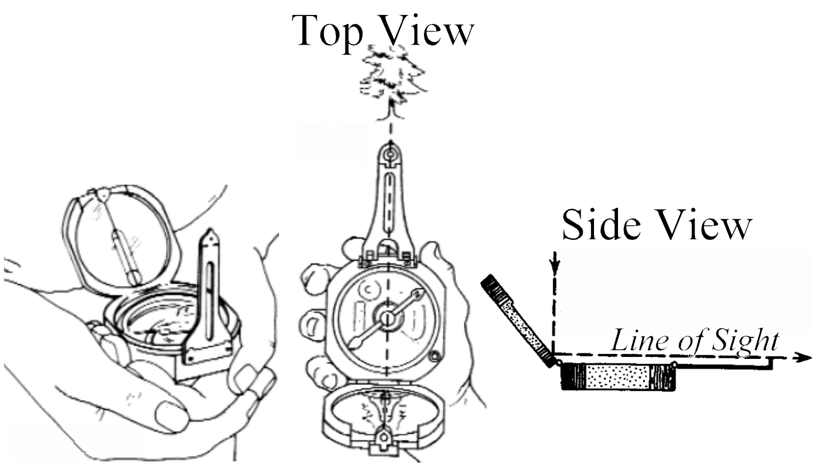
Method 1: Azimuth Measurement Waist-Level "N" End of Needle

- Object lies as much as 45° above, or 15° below observer
- Use "N" end of needle



WARNING! MAKE SURE THERE IS NOTHING MAGNETIC OR IRON IN YOUR WAIST AREA: IRON BELT BUCKLES, RIVETS, ROCK HAMMER, ETC. WARNING!

1. Hold transit waist high and in your left hand.
2. Open cover toward your body to approximately 45°.
3. Open large sight, until perpendicular to the body. (See fig.)



4. Press left forearm against waist and steady with right hand.
5. Level compass using round bubble level.
6. Look into mirror, and bisect the large sight and the object with mirror center line. (See fig.)

- <u>*Always check that bubble is centered in round bubble level*</u>.

7. Read azimuth where "N" end of needle points at graduated circle.

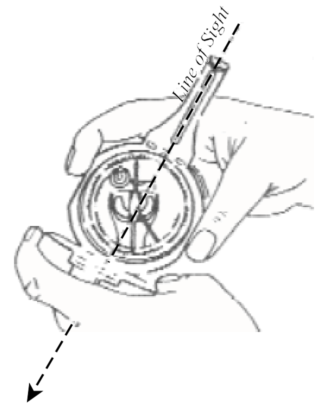
Hint: If object is more than 45° above you, open mirror further toward your body, and adjust large sight so that it leans over the bottom case.

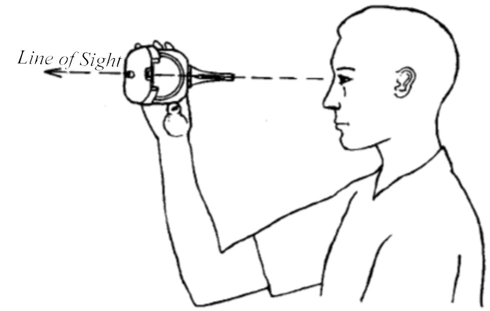
This method is very successful for accurate readings because you are steading the instrument against your body.

WARNING! MAKE SURE THERE IS NOTHING MAGNETIC OR IRON IN YOUR WAIST AREA: IRON BELT BUCKLES, RIVETS, ROCK HAMMER, ETC. WARNING!

<u>Method 2 - Incline by Eye Sight (Straight Line)</u>

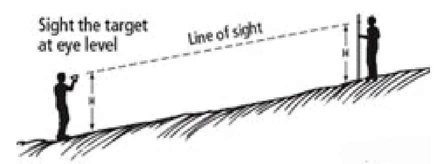
Sometimes direct measurements are not possible because of the surface material or a slope average approximation over a larger distance is desired. In this case, holding the pocket transit and sighting on a slope while reading the clinometer is another option.





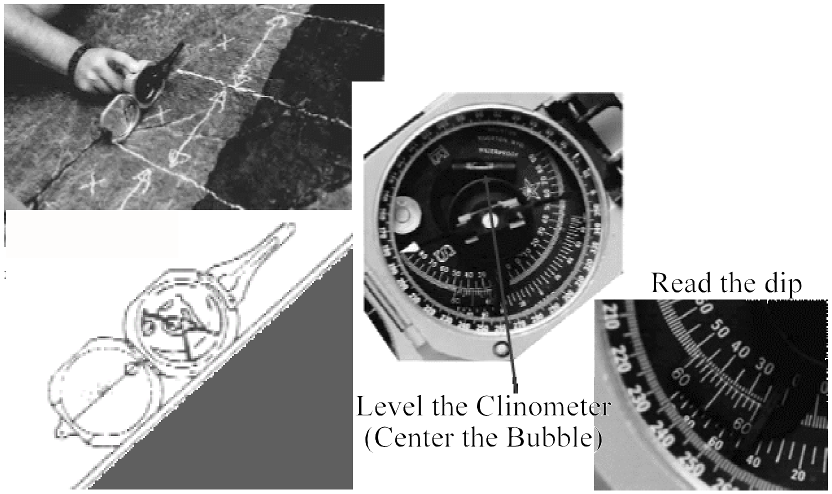
1. Open small sight and large sight as far as possible.
2. Flip peep sight up on large sight.
3. Position Cover to approximately 45°.
4. With large sight pointing toward you, position transit at eye-level with cover open to the left. (See fig.)
5. Sight object behind transit, aligning small sight, window and peep sight with object.
6. In mirror, adjust vernier until bubble in long level is centered.
7. Read inclination or percent grade at vernier's center line.

Make sure you sight on an object downslope or upslope that has the same eye height as you. You may want to pick a tree and mark it at your eye height with some colorful tape.



Method 1 - Incline by Direct Contact

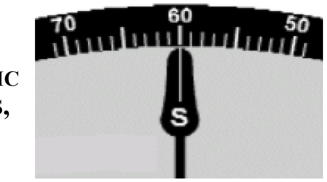
This method is preferred because it is the most accurate. Place Brunton™ directly on the slope to be measured as depicted. If slope is bumpy or uneven, use the clinometer on a ridged flat object, like your field notebook.



1. Place the Brunton™ Pocket Transit in an upright position parallel with the slope as depicted.
   a. *Make sure you get the actual slope (steepest incline) and not an apparent slope. Splashing a little bit of water on an outcrop might help, since water will always run down the steepest slope.*
2. Exactly center the bubble on the clinometer level without moving the compass.
3. You may now remove the compass and read the clinometer dip exactly.
4. Use your handlense to more precisely determining vernier subdivisions on your clinometer.
5. Record your measurements.

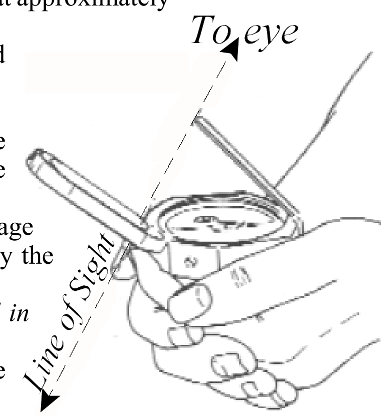
Method 2: Azimuth Measurement Waist-Level "S" End of Needle

- Object lies more than 15° below observer
- Use "S" end of needle



WARNING! MAKE SURE THERE IS NOTHING MAGNETIC OR IRON IN YOUR WAIST AREA: IRON BELT BUCKLES, RIVETS, ROCK HAMMER, ETC. WARNING!

1. Hold transit waist high and in your left hand.
2. Open cover away from your body to approximately 45° from level. (See fig.)
3. Open large sight, until it leans over the body at approximately 45°. (see fig)
4. Press left forearm against your waist and steady with right hand.
5. Level compass using round bubble level.
6. Look just over the large sight, and at the object through window opening on mirror. (See fig.)
   - Adjust mirror and large sight so the image of the large peep sight are bisected by the mirror center line.
   - *Always check that bubble is centered in round bubble level.*
7. Read azimuth where the "S" end of needle points at the graduated circle.

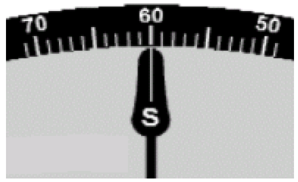


This method is NOT as accurate since you will have to hold the instrument slightly away from your body. Hence it is more difficult to steady and get exact readings.

WARNING! MAKE SURE THERE IS NOTHING MAGNETIC OR IRON IN YOUR WAIST AREA: IRON BELT BUCKLES, RIVETS, ROCK HAMMER, ETC. WARNING!

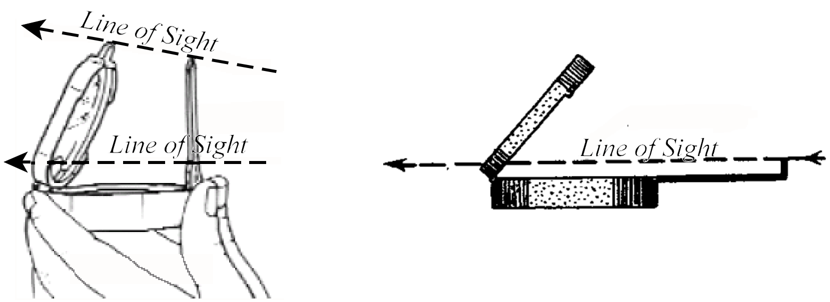
Method 3: Azimuth Measurement Eye-Level "S" End of Needle

- Use when methods 1 or 2 will not work, or when eye level reading is preferred.
- Use "S" end of needle



WARNING! MAKE SURE THERE IS NOTHING MAGNETIC CLOSE TO THE INSTRUMENT. WARNING!

1. Open cover away from your body to approximately 45°, and open small sight. (See fig.)



2. Lift large sight until perpendicular to the body, or leans slightly away from the base. (See fig.)
3. Hold instrument at eye-level, with large sight toward you.
4a. Align large sight and small sight on top of the cover with object.

OR

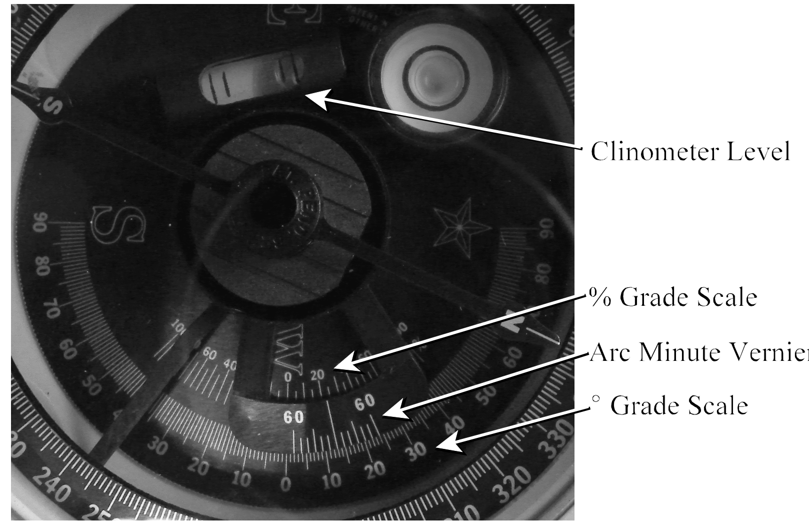
4b. Sight object through the lower portion of large sight and the window in the mirror.
5. Level round bubble level in the reflection of the mirror.
6. Read azimuth in the reflection of the mirror, where the "S" end of needle points at the graduated circle.

This method is probably the most difficult since you have to hold the instrument away from your body. Like shooting a gun, either exhale or hold your breath when taking a reading to help steady the aim.

WARNING! MAKE SURE THERE IS NOTHING MAGNETIC CLOSE TO THE INSTRUMENT. WARNING!

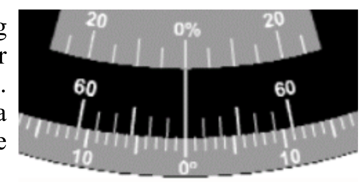
Slope or Incline Measurements

The Brunton™ Pocket Transit is capable of measuring vertical angles with accuracy better than 1°, with readings to 10 arc minutes. It can also display percent grade, without any calculation.

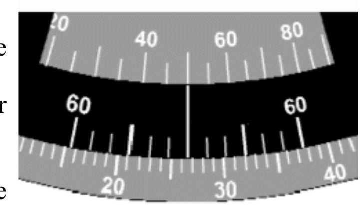


How to read the Brunton™ Clinometer vernier scale:

Vernier scales allow for precision reading of much smaller increments, in this case angles within 10 arc minute accuracies. (0-60 min. with 10 min. increments).



When reading is exactly on a degree marking (example 0°), 60 arc minute markings on vernier also align exactly with a mark on the degree scale. However, when reading is often off-set from a degree marking, 60 arc minute vernier markings are also off. In this case:



1. Read inclination at vernier's center line (Example: 26° + ??).
2. Find minutes by determining which vernier min. line is closest to a degree marking.

- *A Loupe or magnifier may be required.*
  Since the vernier 30 min. line is closest , the total angle is 26° + 30' (26° 30' or 26.50°)