Survey Basics Made Easy?

Questions, Comments, Criticisms & Corrections Welcome.

CAB

12-90

BASIC GENERAL INFORMATION

80 CHAINS = 1 MILE = 5,280 Ft.
1 CHAIN = 100 LINKS = 66 Ft.
1 LINK = 7.92 inches = .66 Ft.
10 SQUARE CHAINS = 1 ACRE = 43,560 FT. SQUARED
1 MILE SQUARED = 640 ACRES = 1 SECTION
1 METER = 3.28083$\overline{3}$ Ft. ($3937/1200$)
6 Sections x 6 Sections = Township.

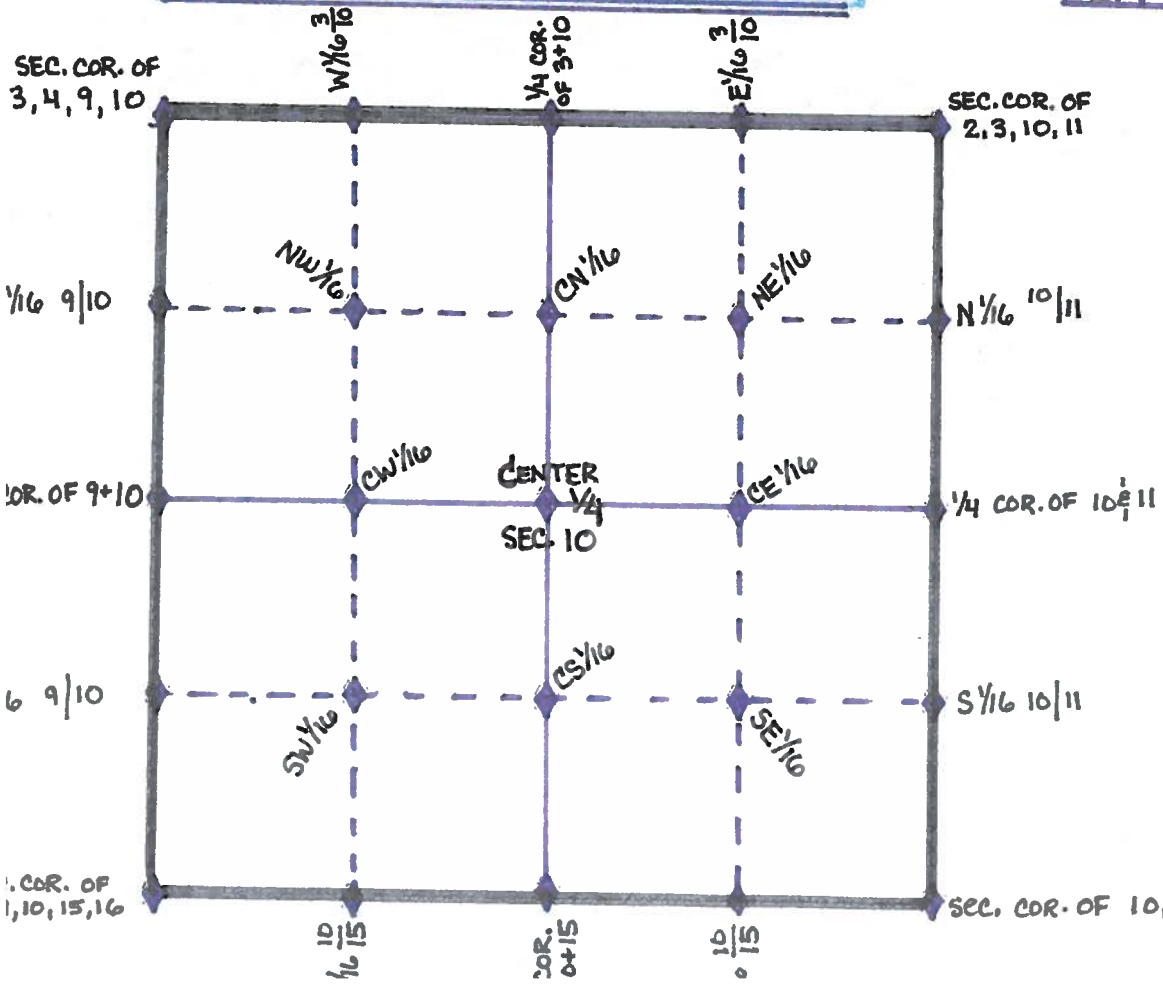
Sections in a township begin with #1 in the NE, Ending with #36 in the SE.

TYPICAL TOWNSHIP

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

★ BE AWARE ALSO OF THE GCDB (Geographic COORDINATE DATA BASE) SYSTEM OF NAMING CORNERS. SEE EXPLAINATION PG. 38. ★

NAMES OF CORNERS in Sec. 10

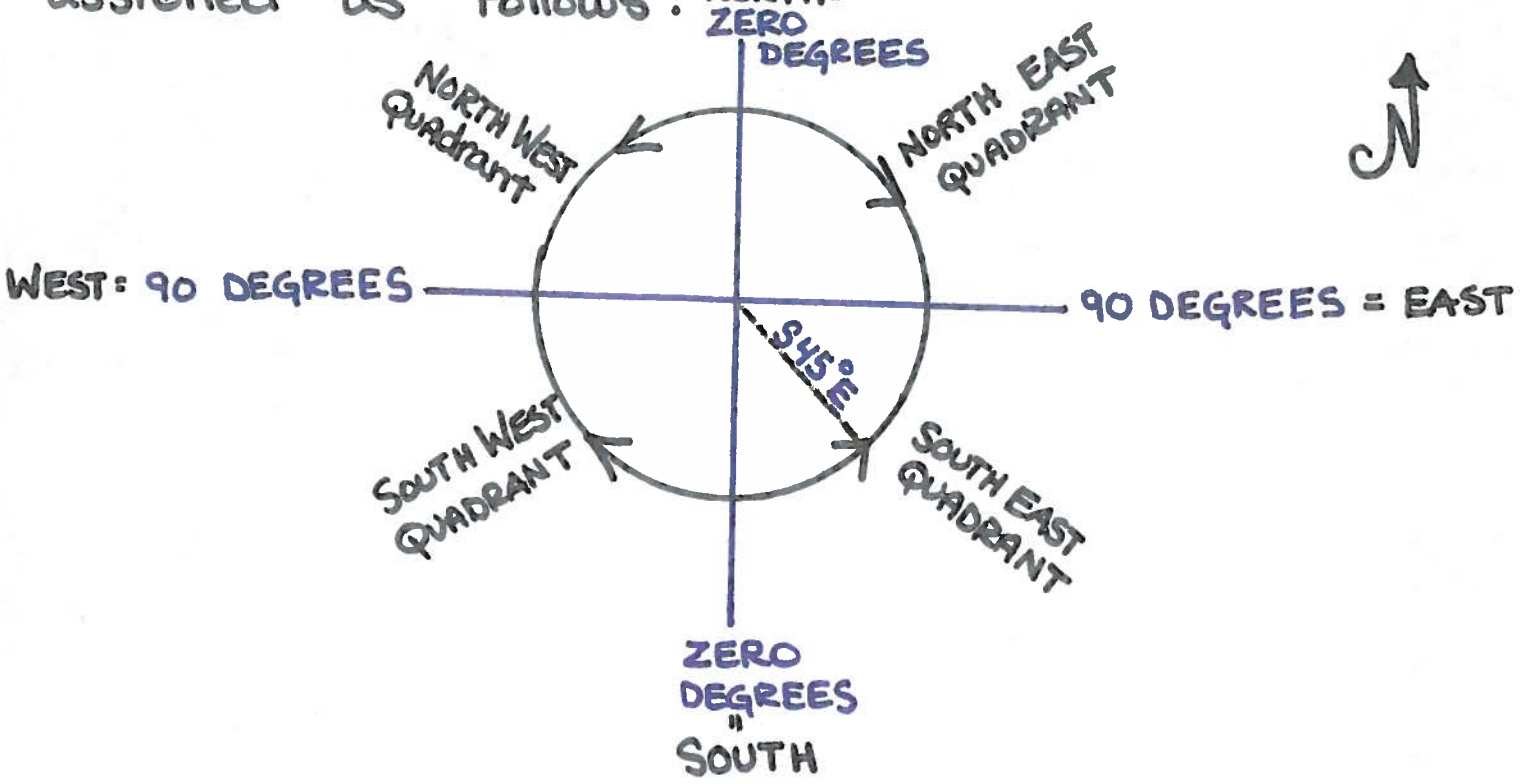


★NOTE★

SEE FORM 9600-14 for further breakdown in Subdivision corner names.

Bearings & Azimuths

A **bearing** is a direction, composed of degrees, minutes, and seconds. There are 4 quadrants that a bearing may fall within, with the degrees being assigned as follows:



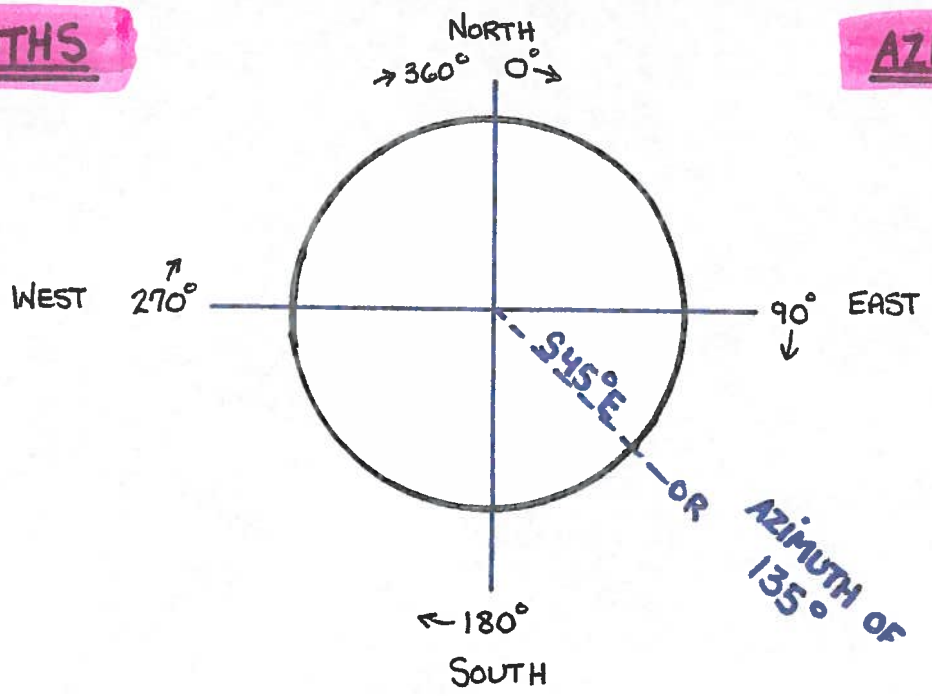
So - there are 90 degrees in each quadrant. A bearing of S45°E will fall exactly in the middle of East + South. Each degree has 60 minutes, and each minute has 60 seconds; much like a clock with hours, minutes + seconds. Due East could be written:

N 89-59-60 E

Azimuths begin with Zero degrees on North, as above, but continue clockwise until ending with 360° on North again.

AZIMUTHS

AZIMUTHS



Like bearings, Azimuths consist of DEGREES, MINUTES, and Seconds.

To Go From A BEARING → TO AN Azimuth

FOR A NE BEARING	DO NOTHING	=	AZIMUTH
FOR A SE BEARING	180° − BEARING	=	AZIMUTH
FOR A SW BEARING	180° + BEARING	=	AZIMUTH
FOR A NW BEARING	360° − BEARING	=	AZIMUTH

To Go From AN AZIMUTH → TO A BEARING

For an Azimuth between 0° + 90°	Do Nothing	=	NE BEARING
For an Azimuth between 90° + 180°	180° − AZIMUTH	=	SE BEARING
For an Azimuth between 180° + 270°	AZIMUTH − 180°	=	SW BEARING
FOR AN Azimuth between 270° + 360°	360° − AZIMUTH	=	NW BEARING

* PRACTICE TO follow .... it is first necessary To know how to **ADD** and **SUBTRACT** items that have DEGREES°, minutes', and seconds"; AS with AZIMUTHS, BEARINGS AND ANGLES.....

ADDING + SUBTRACTING DEGREES°, MINUTES ' + SECONDS "

Adding or Subtracting **DEGREES** in bearings, azimuths, or angles, does not differ from traditional addition or subtraction .... EXAMPLE ... $45^\circ + 10^\circ = 55^\circ$ OR // $90^\circ - 30^\circ = 60^\circ$.

HOWEVER, when minutes and seconds are involved SINCE

60 SECONDS = 1 Minute and
60 minutes = 1 DEGREE,

it is necessary to think of it in terms of 60 = 1 UNIT of the next HIGHER VALUE.

EXAMPLE: ADD $50^\circ\ 30'\ 45''$
$+\ 30^\circ\ 40'\ 35''$

① ADD SECONDS FIRST; CARRY 1' TO minutes column.

$80'' = 1' + \boxed{20''}$

1'

$71' = 1^\circ + \boxed{11'}$ ② ADD MINUTES column; CARRY 1° TO DEGREES column.

1°

$\boxed{81^\circ}$ ③ ADD DEGREES COLUMN

SOLUTION: $81^\circ 11' 20''$

Subtraction is done the same way, but it is sometimes helpful to "borrow" A DEGREE TO BEGIN with.

EXAMPLE:

Subtract $180^\circ\ 00'\ 00''$ → CONVERT TO → $179^\circ\ 59'\ 60''$ (EQUALS THE SAME!)
$-\ 40^\circ\ 15'\ 25''$ $-\ 40^\circ\ 15'\ 25''$

SOLUTION = $139^\circ\ 44'\ 35''$

PRACTICE

Convert Bearings to Azimuths & Azimuths to Bearings Using Addition + Subtraction

IF BEARING IS: →	THEN AZIMUTH IS:
1. N 15-36-45 E	15-36-45
2. S 80-51-20 E	99-08-40
3. S 60-14-34 W	240-14-34
4. N 73-48-50 W	286-11-10

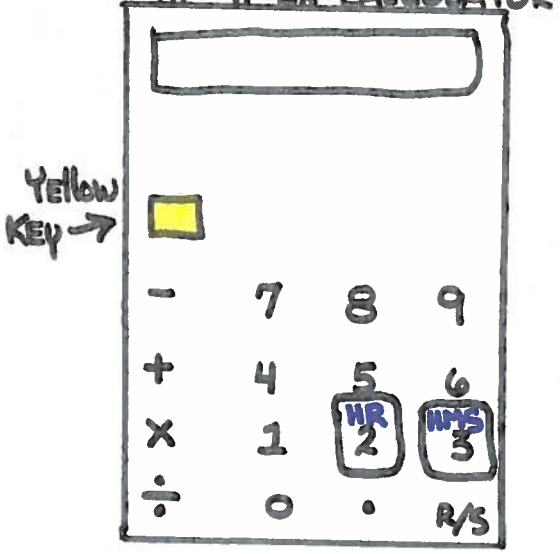
IF AZIMUTH IS: →	THEN BEARING IS:
1. 85-57-10	N 85-57-10 E
2. 146-29-37	S 33-30-23 E
3. 237-18-02	S 57-18-02 W
4. 325-47-28	N 34-12-32 W

HR (hours) + HMS (hours, minutes, seconds) Functions

A speedier method to +, −, ×, or ÷ bearings, azimuths, or angles; is to use the HR (hours) Function. This function takes °, ′, ″ and puts it in terms of a decimal. HMS takes something in decimal form back into Degrees°, Minutes′ + seconds″.

HR + HMS functions may be assigned to any key. Typically, in Az., they have been as follows:

HP 41 CX CALCULATOR



The yellow key, called the SHIFT key, let's you access the functions above each key.

For this example:
HR found @ Shift 2
HMS found @ Shift 3

ADD: 16° 45′ 35″
+ 30° 25′ 50″
47° 11′ 25″

KEY STROKES:

		DISPLAY
1. Key in 16.4535	> Puts °, ′, ″ into HR	16.7597
2. Shift 2		
3. Key in 30.2550	> Puts °, ′, ″ into HR	30.4306
4. Shift 2		
5. +	— ADD THE 2 NUMBERS IN HR	47.1903
6. Shift 3	— Puts the sum back into °, ′, ″	47.1125

SOLUTION: 47° 11′ 25″

PRACTICE

USE HR + HMS TO +, −, x, ÷

	PROBLEM				SOLUTION
1.	71-18-50	+	83-02-40	=	154-21-30
2.	101-23-16	+	2-59-31	=	104-22-47
3.	68-45-53	−	12-40-29	=	56-05-24
4.	350-12-56	−	329-49-10	=	20-23-46
5.	336-25-15	÷	4	=	84-06-19
6.	25-23-40	÷	8-01-20	=	3-09-56
7.	37-49-12	x	2	=	75-38-24
8.	0-19-39	x	12-56-20	=	4-14-15

NOTE: I interchangeably USE DASHES INSTEAD of the °; ′; and ″ symbols.

HMS+ AND HMS- Functions

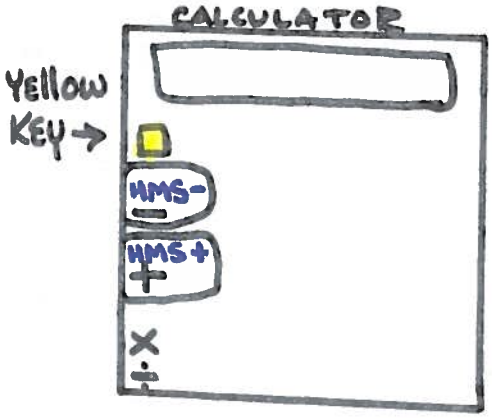
OK - so far we've learned 2 methods to add or subtract, bearings, azimuths, and angles.

1. Do it manually.
2. Use the HR and HMS functions.

Here's the final, and fastest method — used for adding or subtracting a bearing, azimuth, or angle already in the Degrees, Minutes, Seconds" format (HMS).

HMS+ adds two items.
HMS- subtracts two items.

Again HMS+ and HMS- functions maybe assigned to various keys.



For this example:
HMS+ found @ Shift +
HMS- found @ Shift -

ADD: $16^\circ\ 45'\ 35''$
$+\ 30^\circ\ 25'\ 50''$

Key Strokes

	DISPLAY
1. Key in 16.4535	
2. <ENTER> (hit ENTER key)	16.4535
3. Key in 30.2550	30.2550
4. Shift +	47.1125

SOLUTION $47^\circ\ 11'\ 25''$

* Practice with #1-4 Previous page.

Program HP33s for HMS+ and HMS-

For example, I will use "P" for hms+ and "O" which shows the +/- on it for HMS-. I wrote these for the greatest economy of program steps.

To program them in you go into program mode

I will use [grn] to designate the greenish left shift key and [purple] for the purplish right shift key. I will then show the face of the key and then the function, as in [R/S:pgrm] meaning pgrm is the grn shifted R/S key.

program mode is then

[grn][R/S:pgrm]

If no other programs are in the calculator you can just start entering, otherwise you might have to step down through the existing using the rocker key in the center top of the calc to scroll through the program.

You might have to copy this into nodepad or something using a courier or other fixed width font to be readable.

[grn][+:LBL][+/-:o] should show up as O0001 LBL O
(Note: first character is the letter 0, rest is the 4 digit program step

```
[+/-]                       O0002  [+/-]
[grn][+:LBL][E:p]             P0001  LBL P
[grn][5:->HR]                P0002  ->HR
[x<>y]                      P0003  x<>y
[grn][5:->HR]                P0004  ->HR
[+]                         P0005  +
[purple][5:->HMS]             P0006  ->HMS
[purple][+:RTN]               P0007  RTN
```

toggle out of program mode with

[grn][R/S:pgrm]

The numbers to add or subtract have to be in the stack just like normal addition or subtraction.

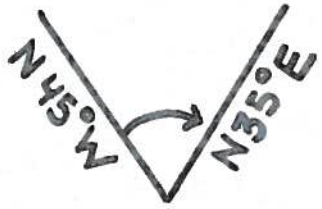
to run hms+ do [XEQ][E:p]
to run hms- do [XEQ][+/i:o]

you are responsible for setting the number of decimal places you want ahead of time using the display key up top right, or you could add a FIX 4 to the program.

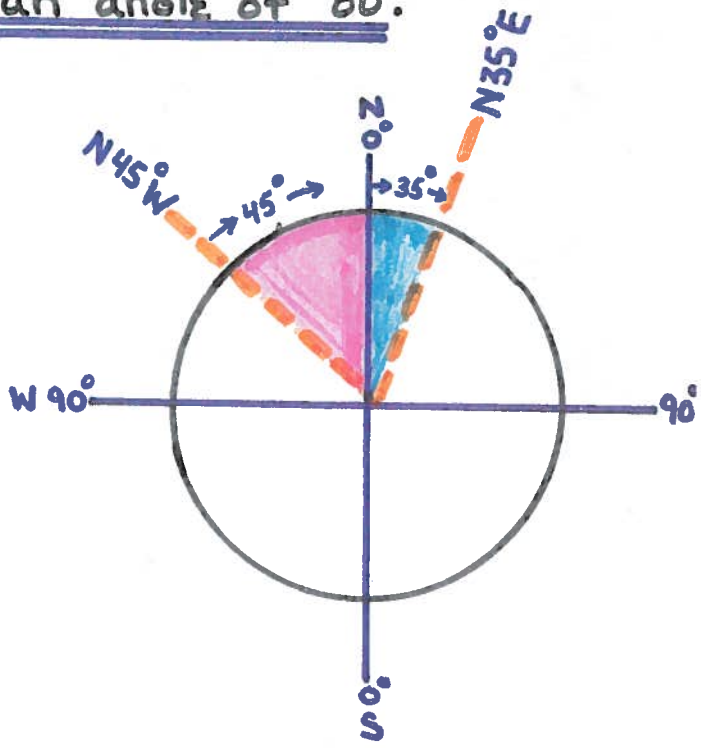
If you want other letters to be used just substitute them when keying in the program.

ANGLES

An **ANGLE** is the difference between 2 bearings OR azimuths.



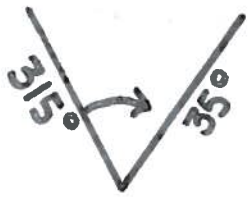
This depicts an angle of 80°.



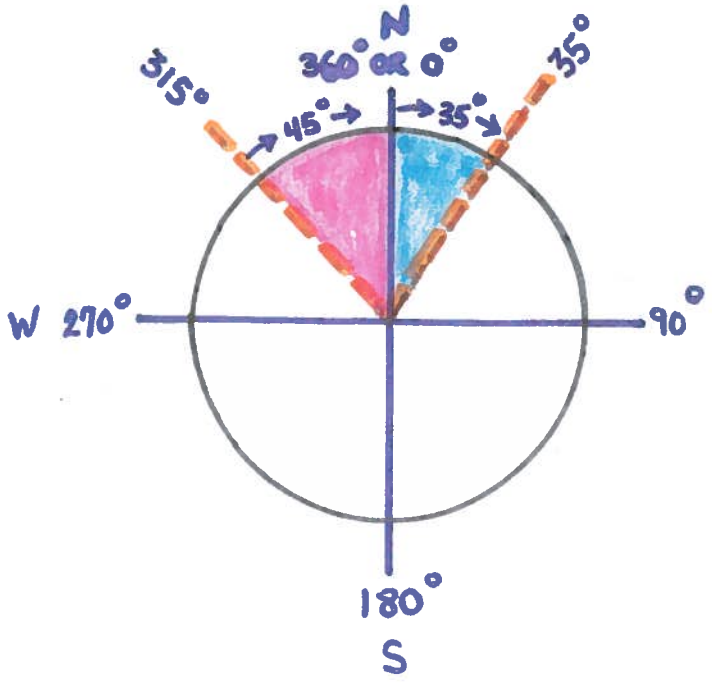
When I'm working in bearings, I look at it as adding or subtracting known parts of the pie.

In this case $45° + 35° = 80°$

It's the same idea for **Azimuths.**

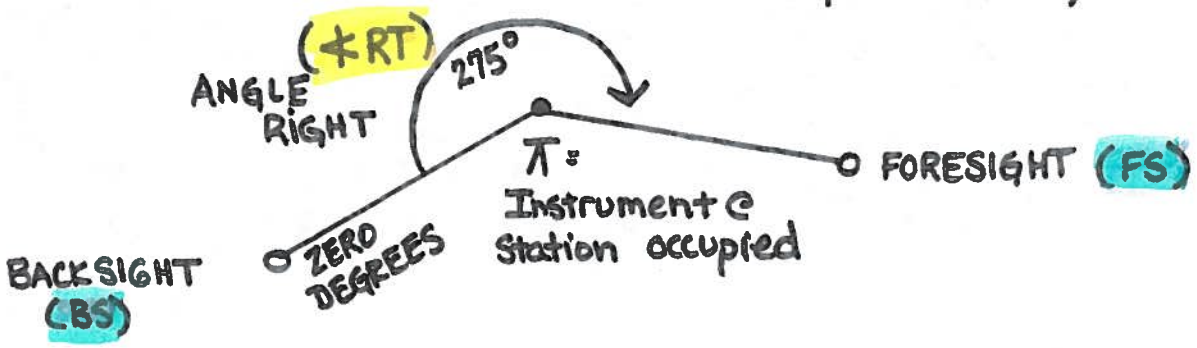


$360° - 315° = 45° + 35° = 80°$



Field Examples of Angles

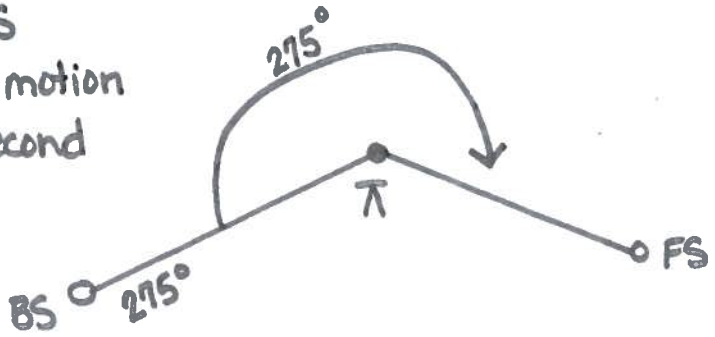
In a typical field situation, ZERO degrees is put on the **Backsight** (usually the point LAST occupied), and an ANGLE to the Right turned to the **FORESIGHT** (Usually the point that will be occupied next).



The **first ∠RT** is 275°. To check human error as well as any error in the alignment of the instrument scope (Collimation), a second angle is turned with the Scope "FLOPPED" 180° or in the opposite direction that it was the first time.

The **Second ∠RT** is ADDED to the first by HOLDING the 275° until it is placed on the backsight (just as ZERO was originally), and then releasing the motion to Allow ∠2 to be Accumulated.

1. Lock 275° in Gun
2. Sight BS
3. Release motion To Add second ∠.



FINDING THE MEAN OF 2 ∢ RIGHTS

To determine if the ∢ RT. turned is GOOD or NOT, the second ∢RT is divided by two to get the MEAN ∢ RT. If the MEAN is within 5 seconds of the FIRST ∢Rt. the ANGLES ARE generally considered to be good, depending on the instrument.

EXAMPLE: ∢RT 1) 20-15-28
2) 40-30-50 ⟩⟩ 3 seconds = OK ANGLES.
m) 20-15-25

NOTE: An instrument will never read more than 360°, so if the first ∢ is greater THAN 180°, you MUST ADD 360° TO ∢2 before dividing by 2.

EXAMPLE: ∢Rt 1) 275-00-00 → Greater than 180°
2) 190-00-00 → (190+360) ÷ 2
m) 275-00-00 = FLAT ANGLE, OK.

PRACTICE: FIND THE MEAN ∢ RT ..... & is it OK?

#1	∢Rt	1) 30-19-50	2) 60-39-40	m)
#2	∢Rt	1) 145-18-22	2) 290-36-50	m)
#3	∢Rt	1) 76-39-48	2) 153-19-25	m)
#4	∢Rt	1) 122-31-39	2) 245-03-00	m)
#5	∢Rt	1) 195-20-20	2) 30-40-50	m)
#6	∢Rt	1) 8-40-30	2) 17-21-20	m)
#7	∢Rt	1) 275-06-12	2) 190-12-37	m)
#8	∢Rt	1) 325-46-01	2) 291-32-02	m)
#9	∢Rt	1) 181-58-45	2) 3-57-42	m)
#10	∢Rt	1) 139-27-19	2) 278-54-45	m)

SOLUTIONS

MEAN ANGLE RIGHT

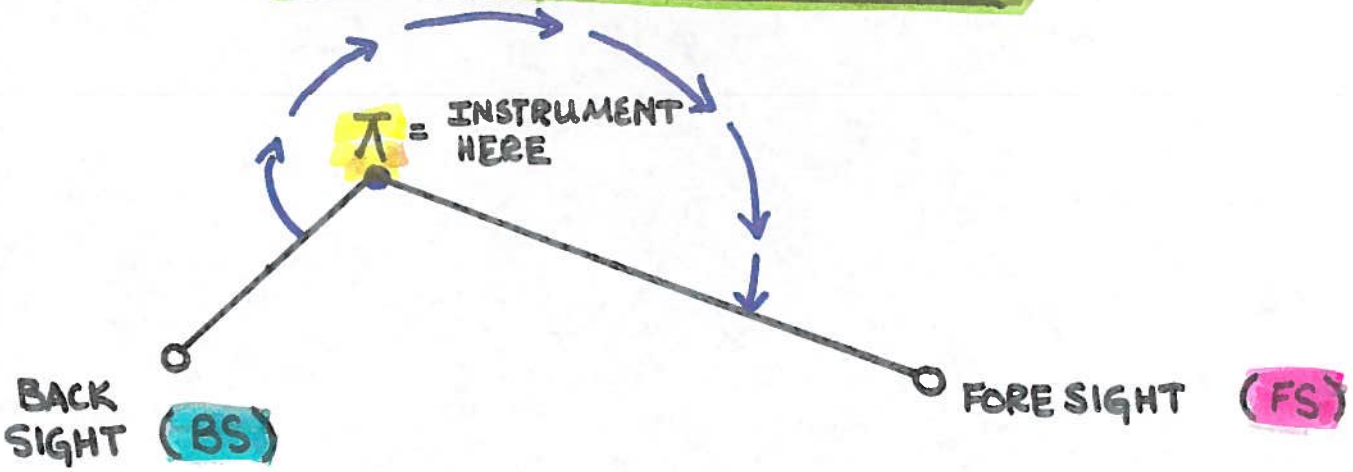
	#2	MEAN		#1	OK?	
#1	60-39-40 ÷ 2 =	30-19-50	COMPARE TO	30-19-50	OK	FLAT
#2	290-36-50 ÷ 2 =	145-18-25	"	145-18-22	OK	3"
#3	153-19-25 ÷ 2 =	76-39-43	"	76-39-48	OK	5"
#4	245-03-00 ÷ 2 =	122-31-30	"	122-31-39	NOT OK	9"
#5	[(360+(30-40-50)]÷2 =	195-20-25	"	195-20-20	OK	5"
#6	17-21-20 ÷ 2 =	8-40-40	"	8-40-30	NOT OK	10"
#7	[(190-12-37)+360]÷2 =	275-06-19	"	275-06-12	NOT OK	7"
#8	[(360+(291-32-02)]÷2 =	325-46-01	"	325-46-01	OK	FLAT
#9	[(3-57-42)+360]÷2 =	181-58-51	"	181-58-45	NOT OK	6"
#10	278-54-45 ÷2 =	139-27-23	"	139-27-19	OK	4"

*(HP41!)

KEY STROKES TO SOLVE #5

	DISPLAY SHOWS
1. Key in #2	30-40-50
2. <ENTER>	30-40-50
3. (*Since #1 is greater than 180°; ADD 360°) Key in 360	360
4. +	390-40-50
5. HR (shift 2)	390-68-06
6. Key in 2	2
7. ÷	195-34-03
8. HMS (shift 3)	195-20-25

MORE FIELD EXAMPLES OF ANGLES

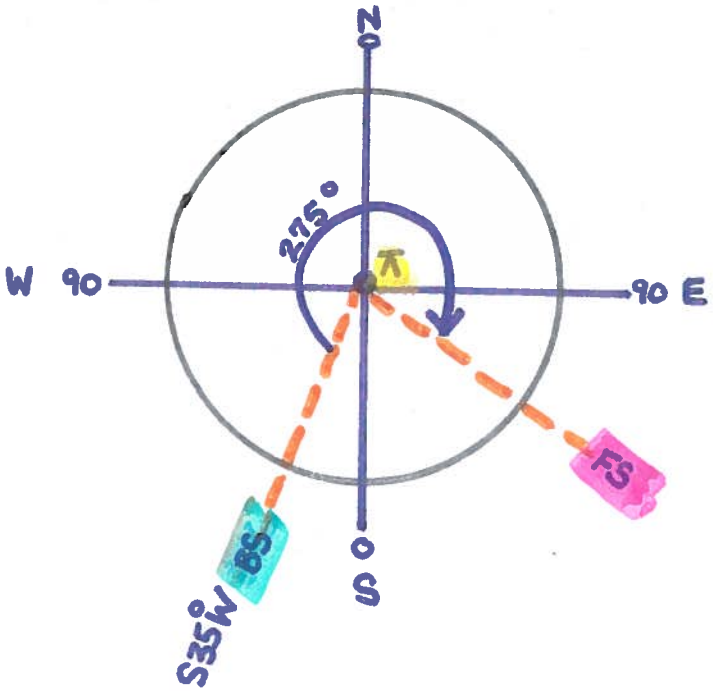


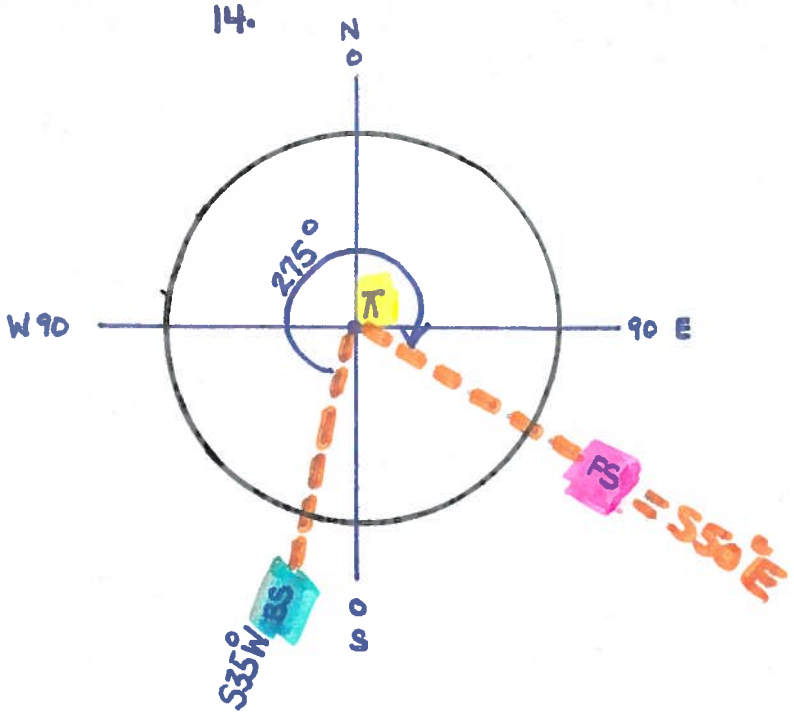
We typically turn our ANGLES from the backsight, TO THE RIGHT, TO OUR FORESIGHT.

*(Most caculator + computer programs ARE set up for using + RT.)

Problem:

If the Backsight bearing is S35°W and the Angle Right is 275° (+ Rt).
WHAT IS THE FORESIGHT BEARING??





Solution: There are several ways to approach this problem, I will explain what works best for me.

#1. Change the BS bearing to an azimuth. $180° + 35° = 215°$

#2. Add to this the ∢ Rt. $215° + 275° = 490°$.

#3. Since we know that a circle can never have more than $360°$; as our example shows, merely subtract $360°$ from the total. $490° - 360° = 130°$

#4. Change the azimuth answer back to a bearing — if desired. $130° =$ S 50° E.

PRACTICE

	BACKSIGHT BEARING	∢ RT	? FORESIGHT BEARING
1.	N 10° E	60°	
2.	S 25° E	175°	
3.	S 89-30-45 W	15°	
4.	N 70-48-00 W	95-20-35	
5.	S 35-08-16 E	315-18-08	
6.	S 50-50-50 W	76-42-31	

NOTE: IT HELPS TO DRAW A SKETCH !!!

Solutions to Adding an + Rt to a BS bearing.

#1. BS bearing = N10°E

Azimuth = 10° + + Rt 60° = Azimuth 70° = FS BEARING **N70°E.**

#2. BS bearing = S25°E

Azimuth = 155° + + Rt 175° = Azimuth 330° = FS BEARING **N30°W.**

#3. BS bearing = S 89-30-45 W

Azimuth = 269-30-45 + + Rt 15° = Azimuth 284-30-45 = FS bearing **N75-29-15W.**

#4. BS bearing = N 70-48-00 W

Azimuth = 289-12-00 + + Rt 95-20-35 = 384-32-35 ★★ NOTE: ★★★

- 360-00-00 ← - 360 !!!!

AZIMUTH = 24-32-35 = FS BEARING **N24-32-35E**

#5. BS bearing = S 35-08-16 E

Azimuth = 144-51-44 + + Rt 315-18-08 = 460-09-52 ★★ OVER 360!!!

- 360-00-00

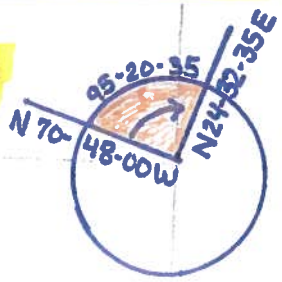
AZIMUTH = 100-09-52 = FS BEARING **S 79-50-08 E**

#6. BS bearing = S 50-50-50 W

Azimuth = 230-50-50 + + Rt. 76-42-31 = Azimuth 307-33-21 = FS BEARING **N52-26-39W**

SKETCH EXAMPLES:

#4.



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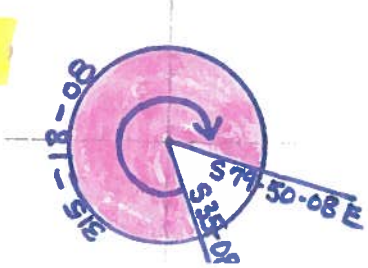

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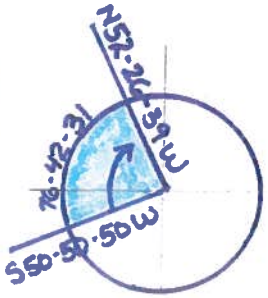
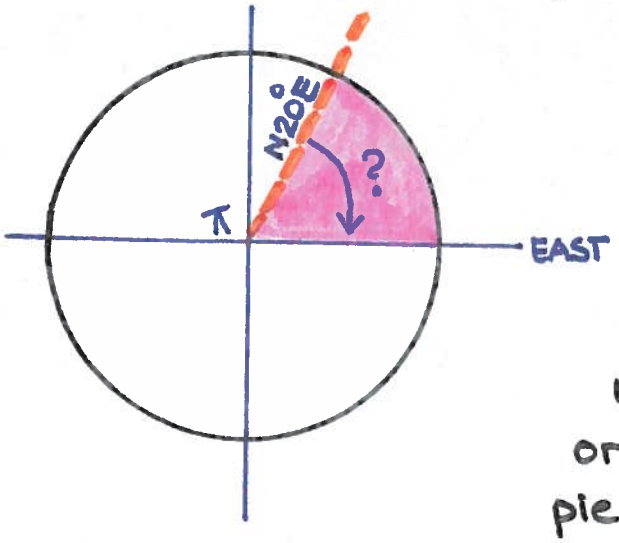


12-90

∢RT Field Angles Continued ∢RT

Following the same principles, it is often necessary to Calculate the **Angle RIGHT** from a known backsight to a desired foresight.

EXAMPLE: Our BS Bearing is N 20°E; we want to go Due EAST, What ∢Rt. do we need to turn.



Again, there are many ways to arrive at a solution, depending on how you look at it.

For ∢Rt's I find it easier to work in bearings, and simply add or subtract what ever pieces of the pie that I need.

In this case 1/4 of the pie = 90° - 20° = ∢Rt 70°.
My best advice is to DRAW A PICTURE.

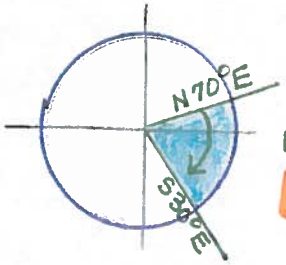
PRACTICE

	BS BEAR.	FS BEAR.	∢RT ?
1.	N 70° E	S 30° E	
2.	S 75° E	S 25° E	
3.	S 40° W	N 55° W	
4.	N 10° W	S 40° E	
5.	N 80° E	N 20° W	
6.	S 5° E	N 75° E	
7.	S 55-40-25 W	S 89-59-50 W	
8.	N 35-15-48 W	S 20-58-36 W	
9.	S 45-10-30 W	N 65-11-21 E	
10.	N 28-28-28 E	N 8-08-08 E	

Solutions to ∢RT PRACTICE

AGAIN - this is just how I'd look at it — find what works best for you!!

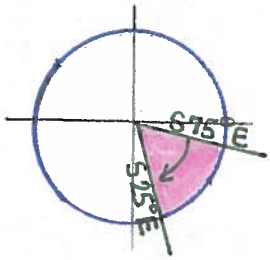
#1



$180^\circ - (70^\circ + 30^\circ) =$

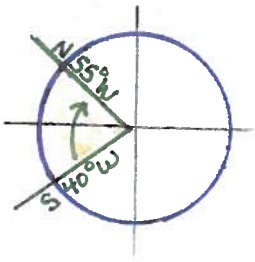
∢Rt 80°

#2



$75^\circ - 25^\circ =$ 50° ∢RT

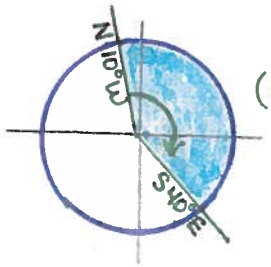
#3



$180^\circ - (40^\circ + 55^\circ) =$

∢Rt. 85°

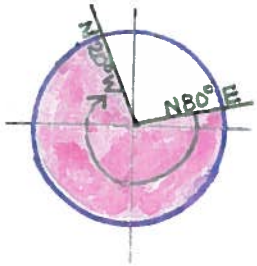
#4



$(180^\circ - 40^\circ) + 10^\circ =$

∢Rt. 150°

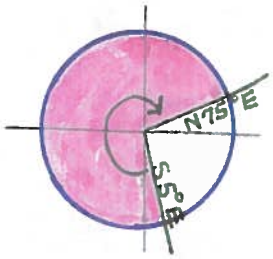
#5



$360^\circ - (20^\circ + 80^\circ) =$

∢Rt 260°

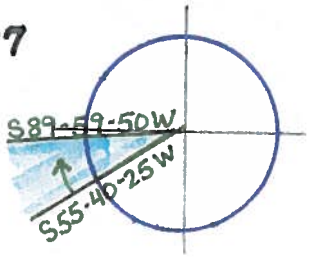
#6



$5^\circ + 180^\circ + 75^\circ =$

∢ RT 260°

#7



89-59-50
− 55-40-25

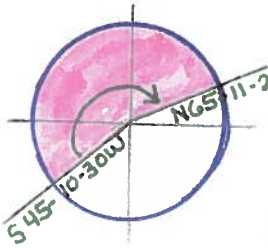
34-19-25 = ∢RT

#8

35-15-48
+ 180-00-00
+ 20-58-36

236-14-24 = ∢RT

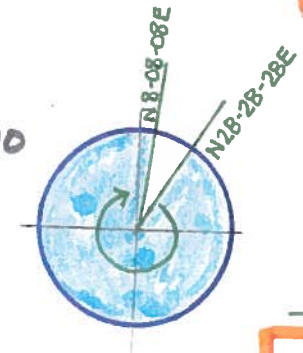
#9



(180-00-00
− 45-10-30)
+ 65-11-21

200-00-51 = ∢RT

#10



360-00-00
−
(28-28-28
− 8-08-08)

339-39-40 = ∢RT.

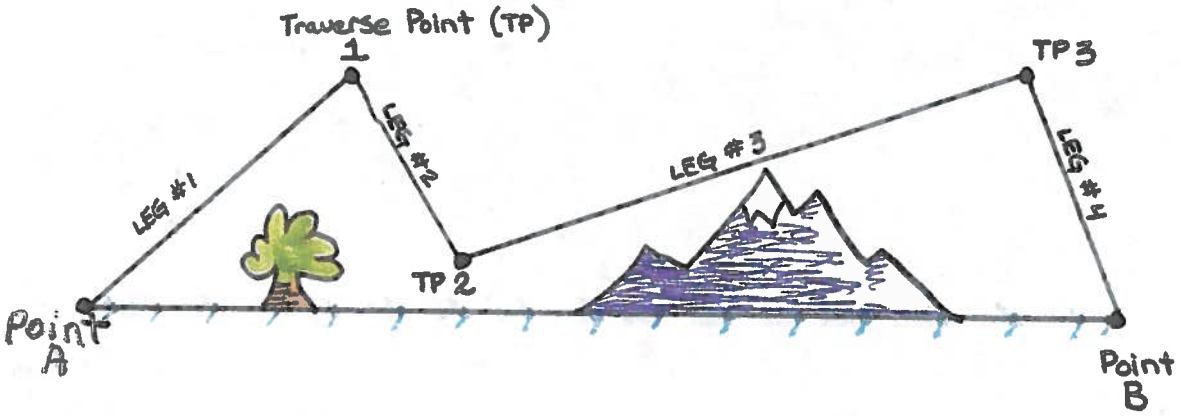
P→R

Latitudes & Departures

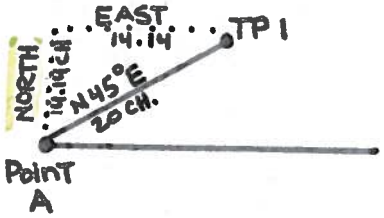
Bearings & Distances

R→P

A survey traverse is the accumulation of many legs (1 bearing; 1 distance) to find the overall bearing and distance between 2 points; when a direct line of sight is not possible, or distances are too great.



If the bearing and distance for Leg #1 is N45°E, for 20 chains; Then, between Point A + TP 1 we have travelled NORTH 14.14 CH. and EAST 14.14 CH.



★ EACH bearing & distance can be broken down into a <u>Latitude</u> (how far we go North or South); and a <u>Departure</u> (how far we go EAST or WEST).

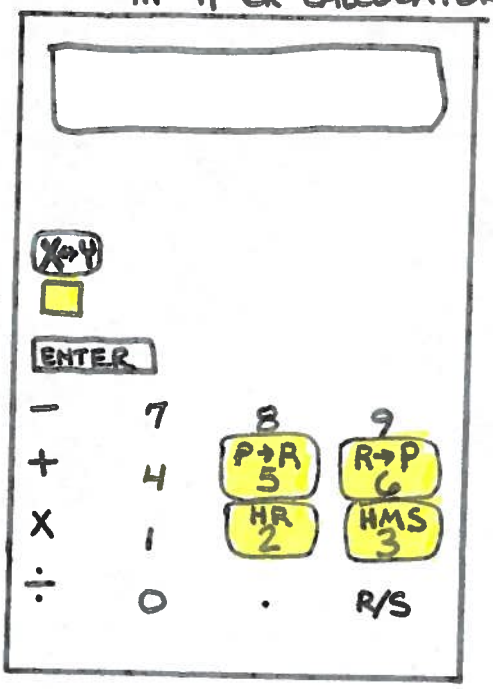
N45°E	=	N 14.14	= <u>RECTANGULAR</u> COORDINATES
20.00		E 14.14	

By the same token, a latitude and departure may be converted into a distance + bearing, the POLAR COORDINATES.

R→P & P→R

The yellow key, called the SHIFT key, lets the calculator access the functions above each key.

HP 41 CX CALCULATOR



Yellow Key →

Note: The location of the HR, HMS functions may Vary!! Check your Key Assignments → SHIFT, CATALOG, &.← (HP 41)

KEY STROKES:

N 45° 35' 30" E, 20 CH.

Polar To Rectangular

1. Key in Bearing (HMS)
2. Shift 2 (Puts into HR)
3. Key in Distance
4. Shift 5 (P→R)
5. Latitude is Displayed.
6. X↔Y
7. Departure is displayed.

EXAMPLE: DISPLAYED:

1. Key In: 45.3530
2. Shift 2 45.5917
3. Key in: 20.00
4. Shift 5
5. Latitude = 13.9953
6. X↔Y
7. Departure = 14.2874

ANSWER: N 13.9953

N 13.9953 E 14.2874

Rectangular to Polar

1. Key in Departure
2. ENTER
3. Key in Latitude
4. Shift 6 (R→P)
5. Distance is displayed.
6. X↔Y
7. Bearing is displayed (in HR)
8. Shift 3 (Puts bearing into HMS)

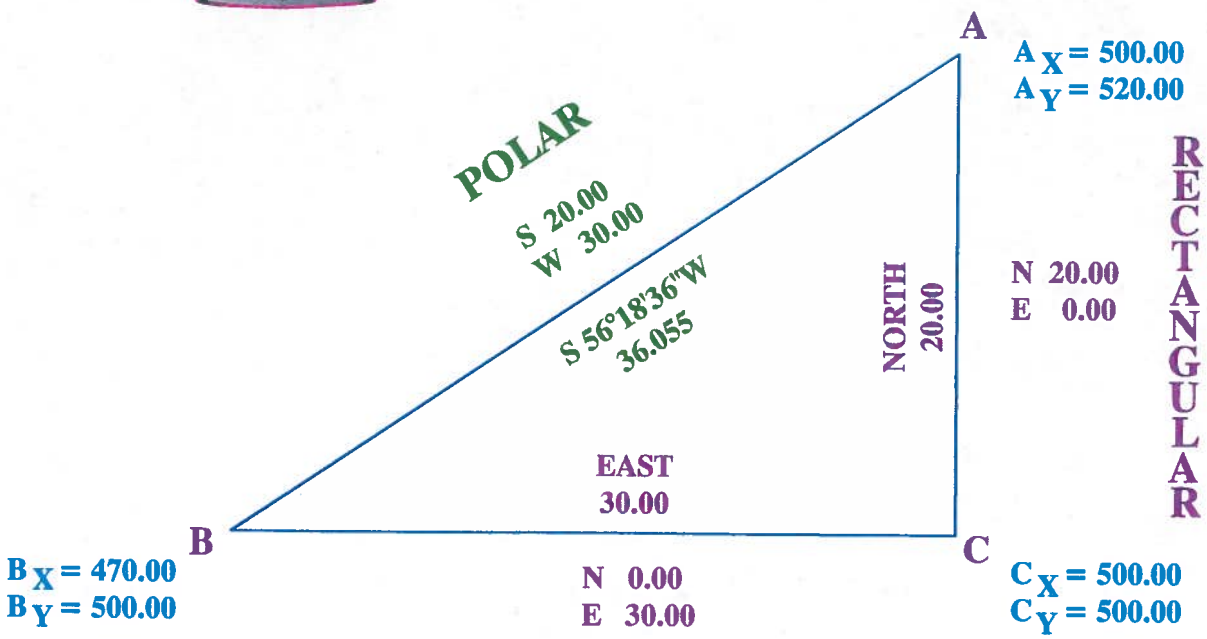
EXAMPLE: DISPLAYED:

1. Key in: 14.2874
2. ENTER
3. Key in: 13.9953
4. Shift 6
5. DISTANCE = 20.0000
6. X↔Y
7. Bearing = 45.5918 (in HR)
8. Shift 3 = 45.3530

ANSWER:

Polar and Rectangular Calculator Functions

*Example using the hp 33s



RECTANGULAR

KEYSTROKES

R to P

1. Key in Departure
2. <Enter>
3. Key in Latitude
4. "Green Shift" + [4]
5. Distance is displayed
6. X <-> Y
7. Bearing is displayed
8. "Purple Shift" + [5] = HMS

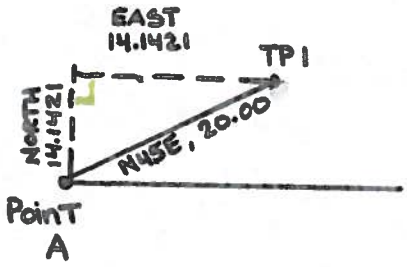
P to R

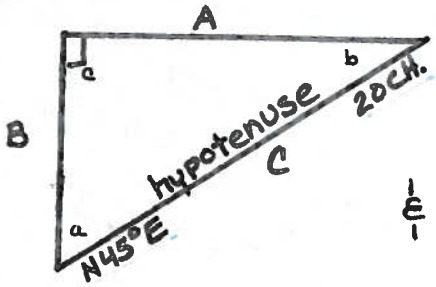
1. Key in bearing
2. "Green Shift" + [5] = HR
3. Key in distance
4. "Purple Shift" + [4]
5. Latitude is displayed
6. X <-> Y
7. Departure is displayed.

R→P & P→R

12-90
&
8-06

Heres the basic mathmetical basis. THE SURVEY leg can be seen as a right triangle, and defined by the Pythagorean Theorem: $A^2 + B^2 = C^2$ } Solves DISTANCE.



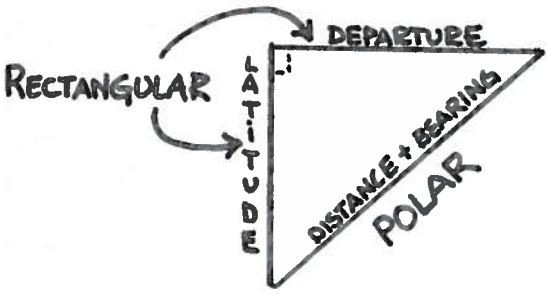


THEN:

& TAN b = B/A
OR
TAN a = A/B
} SOLVES ∠'s

ie $14.1421^2 + 14.1421^2 = 20^2$

* To go from a bearing & distance to a latitude & departure (AND BACK), quickly → (See Box for HP 33s ↘) → → HP 41 CV & CX calculators have a P→R, R→P function, or POLAR → Rectangular.



← + → θ, r	= Lat. & Dep. TO Br. & Dist.
↱ + → y, x	= Br. & Dist. TO Lat. & Dep.

* Key strokes

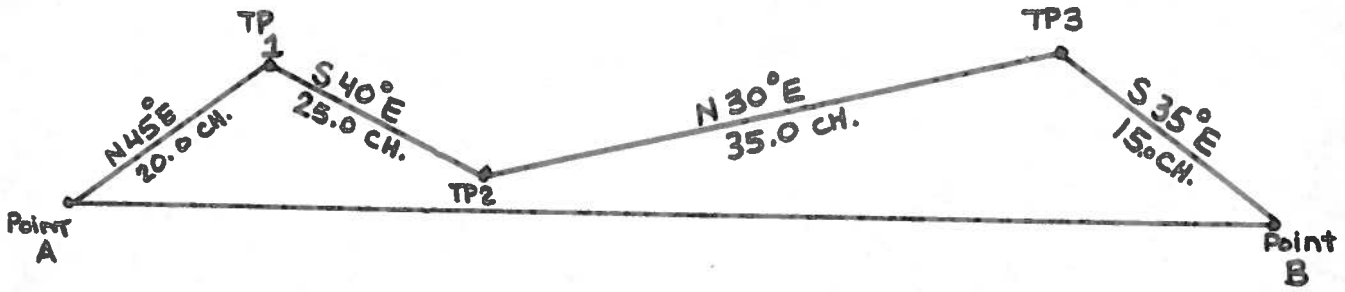
* **P→R** - takes a bearing + distance and converts to a latitude + departure.

R→P - takes a latitude + departure and converts to a bearing + distance.

R→P
1. Key in Departure
2. Enter
3. Key in Latitude
4. 'Green Shift' + 4
5. Distance is displayed.
6. X↔Y
7. Bearing is displayed (in HR)
8. 'Purple Shift' + 5 = HMS

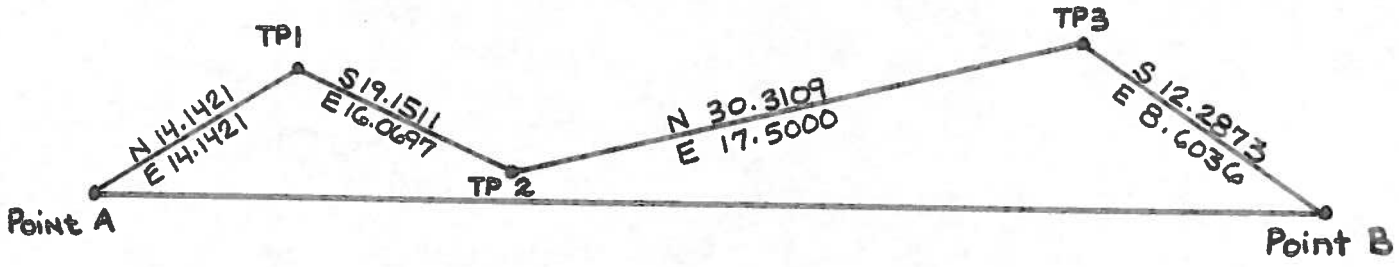
P→R
1. Key in Bearing (HMS)
2. 'Green Shift' + 5 = (HR)
3. Key in Distance
4. 'Green Shift' + 4
5. Latitude is displayed
6. X↔Y
7. Departure is displayed.

12-90



GIVEN the above distances & bearings; Calculate the latitude + departure for each leg of the traverse.

	BEARING	Distance	Latitude	Departure
1.	N 45° E	20.00	N 14.1421	E 14.1421
2.	S 40° E	25.00	S 19.1511	E 16.0697
3.	N 30° E	35.00	N 30.3109	E 17.5000
4.	S 35° E	15.00	S 12.2873	E 8.6036
MORE PRACTICE				
5.	S 89-59-30 W	16.54	S 0.0024	W 16.5400
6.	N 73-21-20 W	12.73	N 3.6463	W 12.1966
7.	S 60-18-47 E	58.22	S 28.8341	E 50.5783
8.	N 0-02-18 E	3.92	N 3.9200	E 0.0026
9.	S 5-59-40 W	79.50	S 79.0653	W 8.3023
10.	N 44-20-30 W	18.31	N 13.0950	W 12.7975
11.	N 38-01-59 E	40.05	N 31.5456	E 24.6754
12.	S 16-49-27 W	00.70	S 0.6700	W 0.2026
13.	S 88-08-10 E	20.89	S 0.6795	E 20.8789
14.	N 70-22-48 W	45.66	N 15.3317	W 43.0090
15.	S 3-15-07 W	5.99	S 5.9804	W 0.3398



Given the above latitudes & departures, Calculate the distance and bearing for each leg of the traverse.

	Latitude	Departure	Distance	Bearing
1.	N 14.1421	E 14.1421	20.0	N 45° E
2.	S 19.1511	E 16.0697	25.0	S 40° E
3.	N 30.3109	E 17.5000	35.0	N 30° E
4.	S 12.2873	E 8.6036	15.0	S 35° E

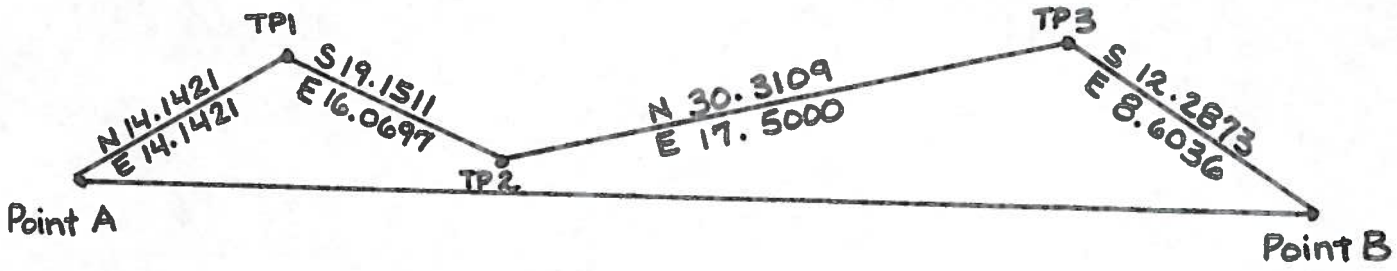
MORE PRACTICE

5.	S 80.0000	W 0.1000	80.0001	S 0-04-18 W
6.	N 13.0000	W 45.0000	46.8402	N 73-53-12 W
7.	N 26.0000	E 51.0000	57.2451	N 62-59-14 E
8.	S 8.0000	E 70.0000	70.4557	S 83-28-49 E
9.	S 39.8888	W 0.5000	39.8919	S 0-43-05 W
10.	N 2.1555	W 20.0000	20.1158	N 83-50-55 W
11.	N 100.0000	E 100.0000	141.4214	N 45 E
12.	S 35.0000	E 10.0000	36.4005	S 15-56-43 E
13.	S 79.3888	W 1.2222	79.3982	S 0-52-55 W
14.	N 16.1786	W 57.0032	59.2546	N 74-09-18 W
15.	N 0.0123	E 0.8546	0.8547	N 89-10-31 E

TOTALS

Totals

TOTALS



* To find the TOTAL (Σ) latitude + departure between Point A and Point B, we simply ADD all the legs together.

→ ASSIGN a positive + Value to all Northings + EASTINGS.

→ ASSIGN a negative − Value to all Southings + Westings.

Summation (Σ) of Latitudes

1. + 14.1421
2. − 19.1511
3. + 30.3109
4. − 12.2873

TOTAL LAT. + 13.0146

= N 13.0146

Summation (Σ) of Departures

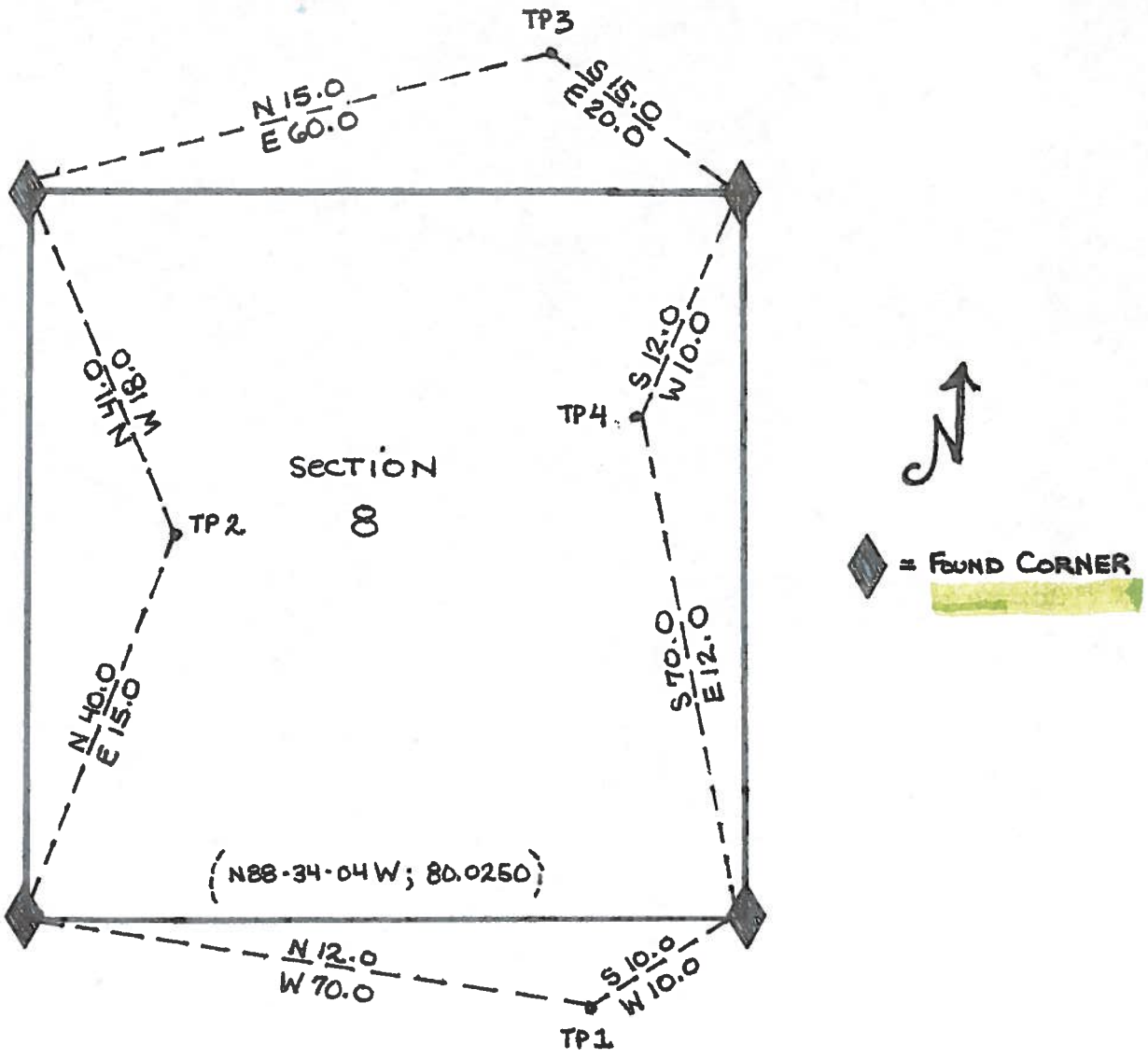
1. + 14.1421
2. + 16.0697
3. + 17.5000
4. + 8.6036

TOTAL DEP. + 56.3154

= E 56.3154

★ N13.0146 E56.3154 > TOTAL LAT. + DEP. BETWEEN point A + point B.

★ N 76·59·14 E 57.7997 > TOTAL Distance + bearing between point A + point B.



Here's a sample traverse around sec. 8. Begin at the SE cor., traverse clockwise around the section. Compute the total distance and bearing between found corners on the perimeter of sec. 8.

South Bdy.	$-10 + 12 = +2.0$ $-10 + (-70) = -80.0$	Σ LAT. = N 2.00 Σ DEP. = W 80.00	=	N88-34-04W 80.0250
WEST Bdy.	$+40 + 41 = +81.0$ $+15 + (-18) = -3.0$	= N 81.0 = W 3.0	=	N 2-07-16W 81.0555

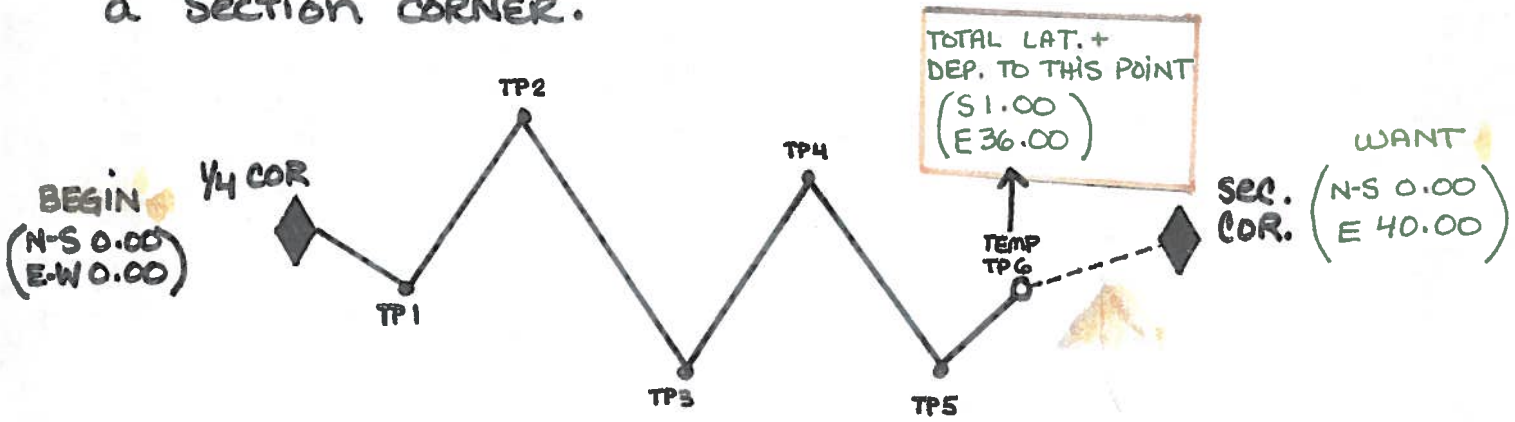
12-90

NORTH Bdy.	$+15.0 + (-15.0) = \pm 0.00$	= N-S 0.00	= EAST 80.00
	$+60.0 + 20.0 = +80.0$	= E 80.00	
EAST Bdy.	$-12.0 + (-70.0) = -82.00$	= S 82.00	= S 1-23-50 E 82.0244
	$-10.0 + 12.0 = +2.00$	= E 2.00	

INVERSING / OR DETERMINING THE BEARING & DISTANCE BETWEEN TWO SETS OF RECTANGULAR COORDINATES.

The proceedure for getting from where you ARE to where you want to GO is called INVERSING.

For instance, we want to traverse from a found ¼ CORNER, DUE EAST for 40 chains, to find a section CORNER.



Beginning with ZERO, and traversing to Temp TP6, the total Latitude + Departure to this point is S 1.00 and E 36.00.

To find how far we need to go to the section corner, it's just a matter of Adding or Subtracting LATS. + DEPS.

ARE @ TP6	WANT for sec. COR.	GO
S 1.00 E 36.00	N-S 0.00 E 40.00	N 1.00 E 4.00 OR N 75-57-50 E 4.12 CH.

A CORNER move is nothing more than inversing from a Temp, to the calculated position for A CORNER.

INVERSING (CONT.)

Hints for solving practice problems: 1. WORK in LATS. + DEPS. 2. PAY attention to Directions; as in adding E's TO W's OR N's to S's. 3. DRAW A Picture — see the relation of where you are TO where you want to go.

PRACTICE

* Go ahead and round Lats. + Deps. To two decimal places *

	You ARE	You WANT	GO BEARING + DISTANCE
#1)	N 16.00 E 50.00	57.87 CH N 71-52-41 E	
#2)	S 10.00 W 15.00	S 59-02-10 W 23.32	
#3)	S 5.00 E 45.00	N 86-25-25 E 80.16	
#4)	N 8.00 E 1.00	S 87-03-52 W 39.05	
#5)	S 5.00 E 4.00	NORTH 40.00	
#6)	N 39.00 W 5.00	N 0-42-58 W 80.01	
#7)	N 45.00 W 5.00	N 14-02-10 E 41.23	

Solutions to Inversing Problems

	ARE	WANT	GO	BR.+ DIST.
#1)	N 16.00 E 50.00	N 18.00 E 55.00	N 2.00 E 5.00	N68-11-55 E 5.39
#2)	S 10.00 W 15.00	S 12.00 W 20.00	S 2.00 W 5.00	S68-11-55 W 5.39
#3)	S 5.00 E 45.00	N 5.00 E 80.00	N 10.00 E 35.00	N 74-03-17 E 36.40
#4)	N 8.00 E 1.00	S 2.00 W 39.00	S10.00 W 40.00	S75-57-50 W 41.23
#5)	S 5.00 E 4.00	N 40.00 W 0.00	N45.00 W 4.00	N 5-04-47 W 45.18
#6)	N 39.00 W 5.00	N 80.00 W 1.00	N 41.00 E 4.00	N 5-34-20 E 41.19
#7)	N45.00 W 5.00	N 40.00 E 10.00	S5.00 E15.00	S 71-33-54 E 15.81

* Step by Step Solution to #4 →

Step by Step Solution to #4 Inversing Problem

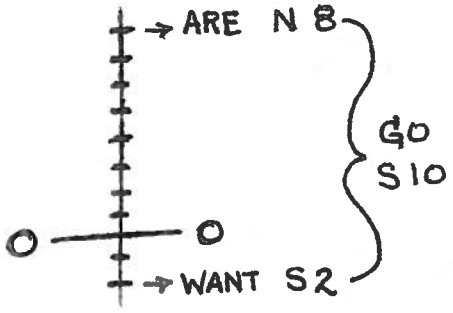
#4

ARE	WANT	GO	BR. + DIST.
N 8.00	S 87-03-52 W	?	?
E 1.00	39.05		

1. Convert where you Want to a Latitude + Departure.

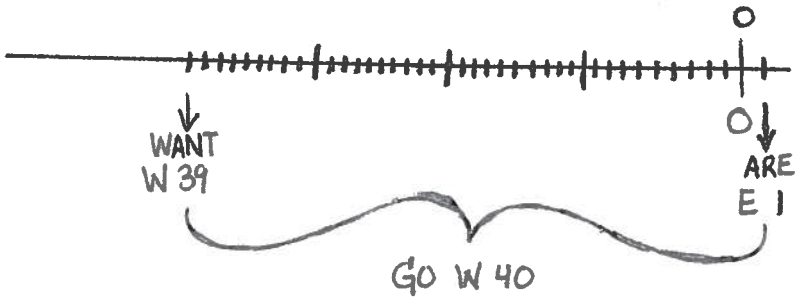
S 87-03-52 W	=	S 2.00
39.05		W 39.00

2. Compare the Lats. Draw a picture. A number line with zero in the middle of north values and south values, works well.



We ARE N 8, to get to S 2, we'd GO a total of **10 CHAINS S.**

3. Compare the Deps. Draw a picture.



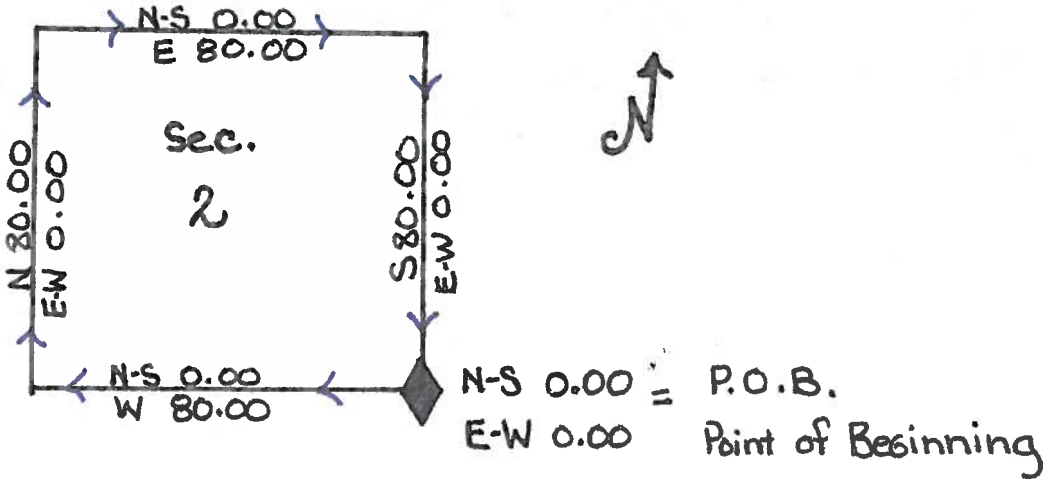
We ARE E 1, to get to W 39, we'd GO a total of **40 chains W.**

4. GO or MOVE

S 10.00	or	S 75-57-50 W
W 40.00		41.23

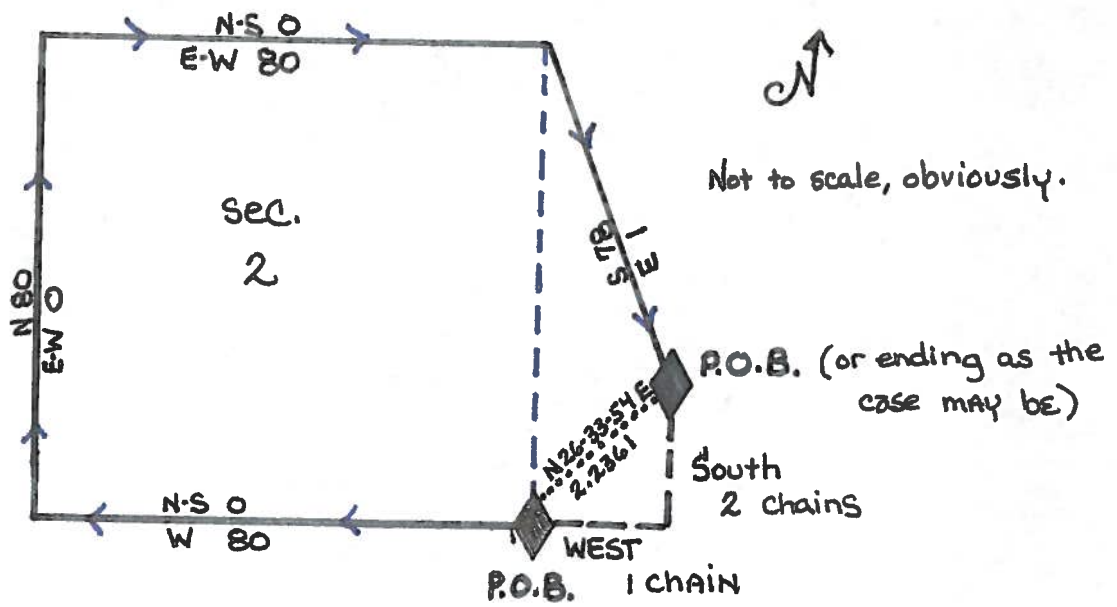
MISCLOSURE, CLOSURE & ERROR

When a traverse begins + ends at the same point, as we just did in the sample traverse around section 8, it is called a CLOSED TRAVERSE. All traverses MUST be CLOSED in order to determine whether any error (human, electronic, mother nature ..... etc.) introduced into the survey is within Acceptable limits.



The beginning Latitude and Departure for a typical traverse is N-S 0.00 + E-W 0.00, (We haven't gone anywhere yet!!). If we begin at the SE cor. of sec. 2 and traverse clockwise around it given the above LATS. + DEPS.; upon CLOSING BACK INTO the SE COR., we would be BACK to LAT. + DEP. of N-S 0.00 + E-W 0.00. This is called CLOSING FLAT, or no error or misclosure, and rarely, if ever, happens.

12-90



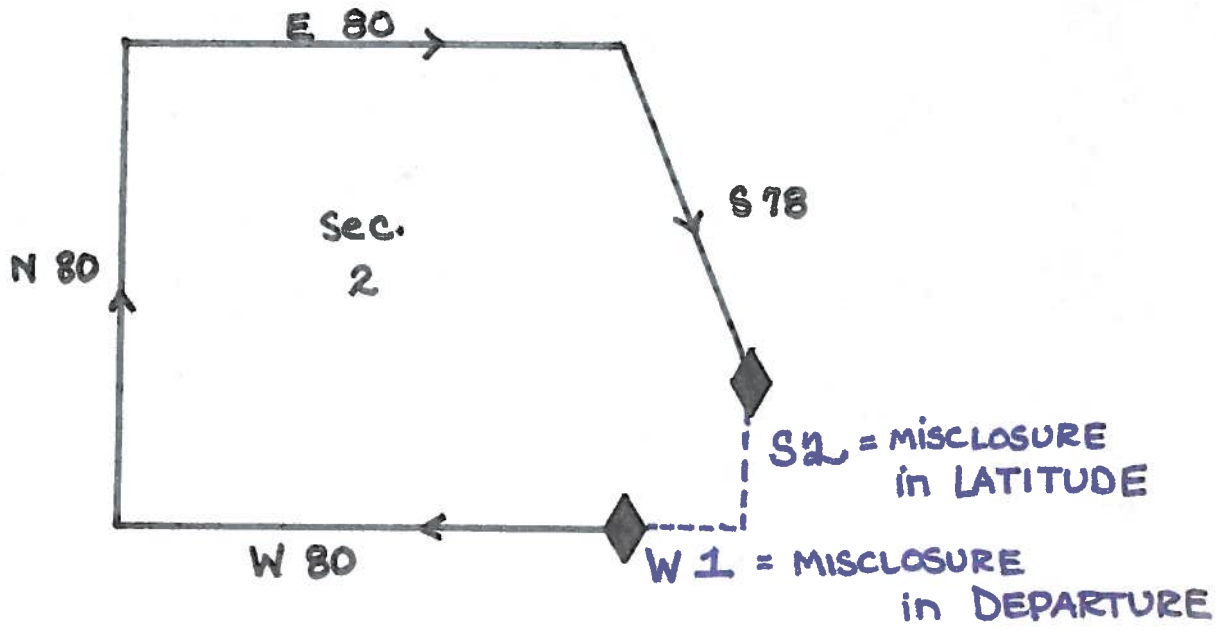
Let's say we begin the traverse at the SE COR. AGAIN, using the above Lats. + Deps. This time upon reaching the P.O.B., the TOTAL of the LATS. + DEPS. does not equal zero, zero. The distance in each direction that we MISS the SE COR. is our MISCLOSURE. We would need to go South 2 chains, and WEST 1 chain to CLOSE FLAT. It is the same to SAY WE ARE 2 chains North and 1 chain EAST of the P.O.B. N2.00 + E 1.00 can be converted into the bearing + distance of the misclosure (LINEAR ERROR OF CLOSURE), which is sometimes helpful in searching for the error if the error is too great, or OUT of OUR Acceptable limits.

How much is TOO much ERROR?

12-90

CLOSURE CLOSURE CLOSURE

Closure can be calculated by dividing the total distance surveyed around the perimeter of a closed traverse, by the misclosure in both the Lat. and Dep., individually.



Using the same Lats. + Deps. for Sec. 2, ADD together (All positive values for this) the total distances (in cardinal directions) travelled around sec. 2.

* 80 + 80 + 80 + 78 = 318 CHAINS = Total horizontal distance around sec. 2. (Σ HD).

Divide the ΣHD by the misclosure in LATITUDE.

$\frac{318}{2}$ = 159 chains.

Divide the ΣHD by the misclosure in DEPARTURE.

$\frac{318}{1}$ = 318 chains.

Limits of Closure

$\frac{\Sigma \text{ HD } 318}{\text{MISCLOSURE LAT.} \quad 2} = 159$ CH.

$\frac{\Sigma \text{ HD } 318}{\text{MISCLOSURE DEP.} \quad 1} = 318$ CH.

For Sec. 2 we would say that our closure in Latitude is 1/159; which means that for every 159 chains travelled, we were 1 chain off, or we would misclose by 1 chain. Likewise, the closure in Departure is 1/318; for every 318 chains travelled, we were 1 chain off. That is a bunch OF ERROR, and we'd say this section DID NOT CLOSE ..... It would be necessary to go BACK in the field and find the problem. So – the LIMITS OF CLOSURE that we are required to return ARE:

- 1/5,000 on any closed survey, using all our own measurments.

OR

- 1/2,500 if our survey uses a record measurment from a previously Approved survey.

In some instances a particuliar jobs' Special Instructions MAY set a different limit of closure depending on the circumstances.

Consequently, the 1/159 and the 1/318 aren't even close to the 1/5000 required. In a section with a perimiter of 320 chains, we'd need an error of closure, of less than 6½ Links to be within the 1/5000 Limit.

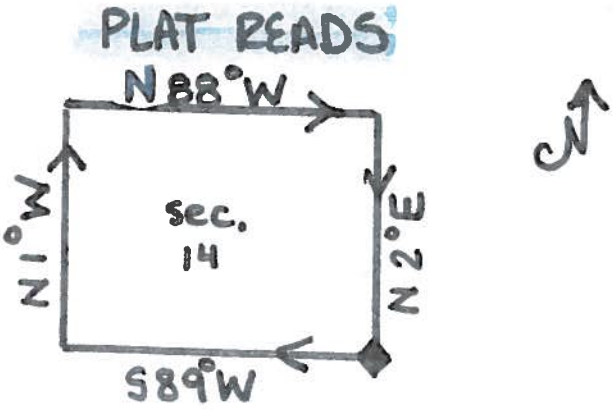
Limits of Closure Practice

FOR EACH of the sections on the following PAGE, FIND:

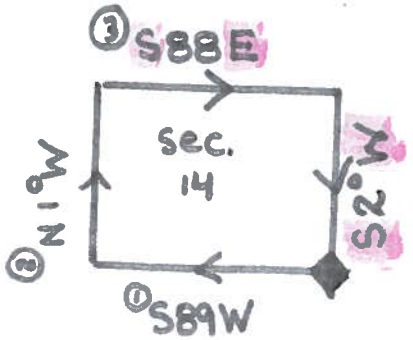
1. Misclosure in LAT.
2. Misclosure in DEP.
3. BEAR. + Dist. of the misclosure.
4. Closure in LAT., $\frac{1}{?}$ is it within limits.
5. Closure in DEP., $\frac{1}{?}$ is it within limits.

NOTE: On a plat, bearings are usually written in terms of WESTING, on E-W lines; and Northing on N-S lines. Don't let it confuse you.... just begin at a corner and proceed clockwise around the section, as you would on the GROUND.

EXAMPLE:

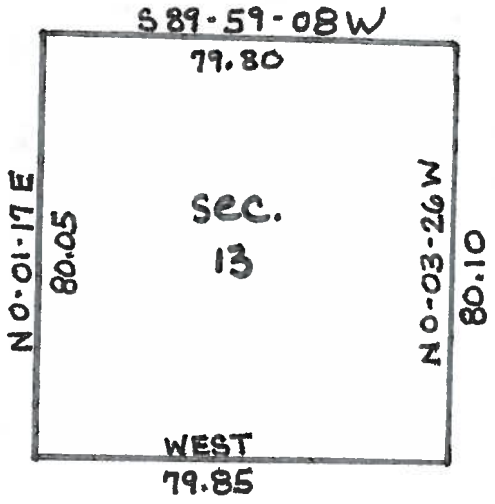


But you can think of it as:



Limits of Closure Practice

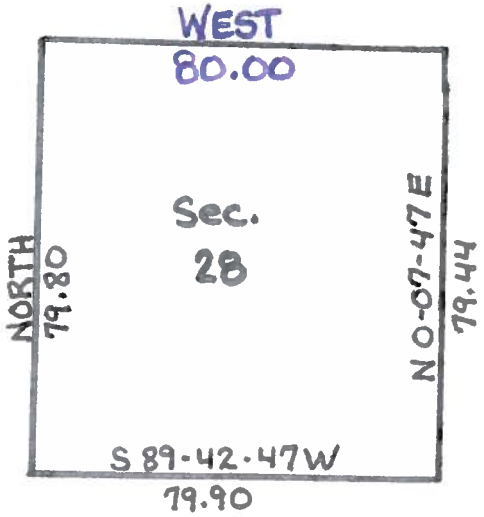
1. Sec. 13 was surveyed using our own measurments.



FIND:

1. Misclosure in LAT.	S 0.03
2. Misclosure in Dep.	E 0.06
3. BEARING + DIST. of the Misclosure	S 63-26-06 E 0.07
4. Closure in LAT.	1/10,660
Is it within limits?	YES
5. Closure in Dep.	1/5,330
Is it within limits?	YES

2. Sec. 28 was surveyed using Record bearing & distance for the North boundary.

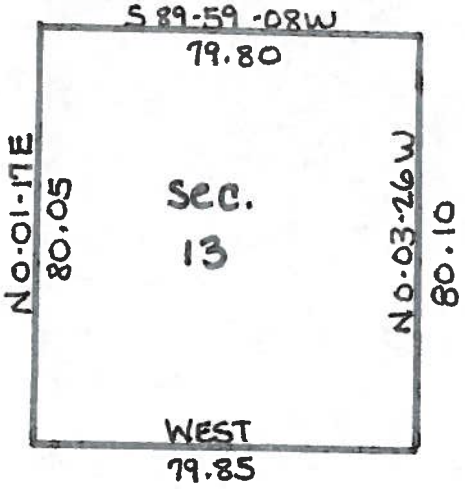


FIND:

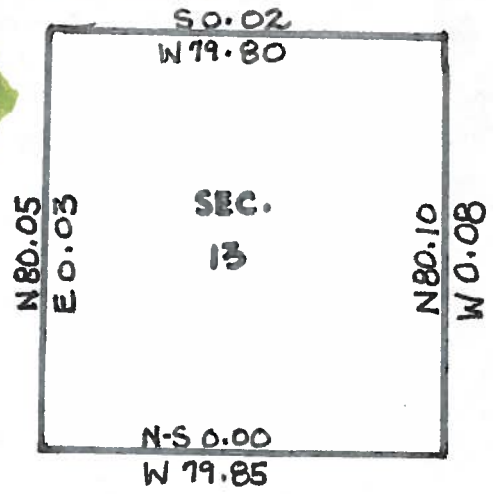
1. Misclosure in Lat.	S 0.04
2. Misclosure in Dep.	W 0.08
3. BEARING + DIST. of the misclosure	S 63-26-06 W 0.09
4. Closure in LAT.	1/7,979
Is it within limits?	YES
5. Closure in Dep	1/3,989
Is it within limits?	YES

Step by step SOLUTION to #1. - Limits of Closure

1. Sec. 13, surveyed using our own measurments.



STEP #1 CHANGE BR.+DIST. TO LAT.+DEP



STEP #2 - Find ΣHD

79.85
80.05
79.80
+ 80.10
319.80 = Σ HD

STEP #3 - Find Misclosure in LAT.

(I'm starting at the SE Cor.)

0.00
80.05
0.02
+ (-80.10)
-0.03 or S 0.03

STEP #4 - Closure in LAT.

$\frac{319.80}{.03} = 10,660$

STEP # 9 BR.+DIST. OF MISCLOSURE

S 0.03 & E 0.06 =
S 63-26-06 E
0.07

STEP #5 - Find Misclosure in. Dep.

(-79.85)
0.03
79.80
0.08
0.06 or E 0.06

STEP #6 - CLOSURE in DEP.

$\frac{319.80}{0.06} = 5,330$

STEP #7 - LAT. WITHIN LIMITS?

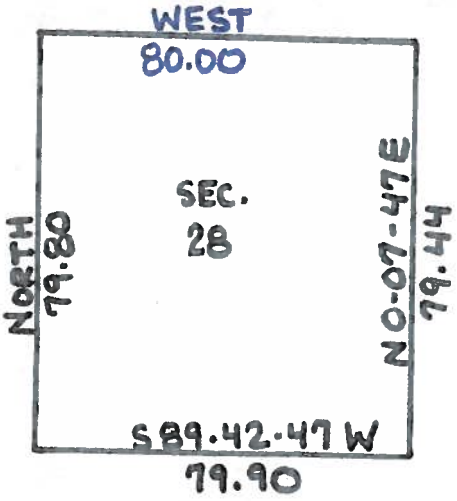
1/10,660 is better than 1/5,000 - YES.

STEP #8 - DEP. WITHIN LIMITS?

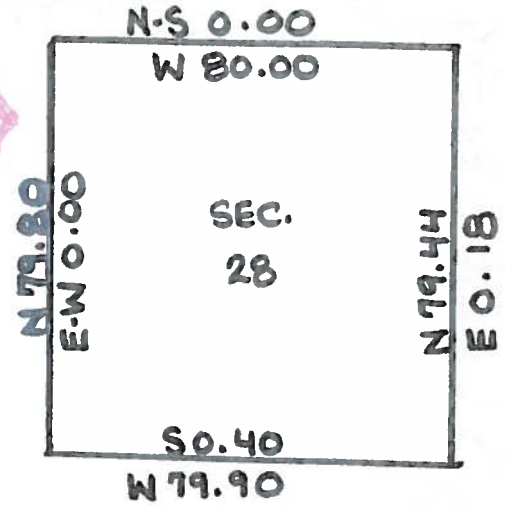
1/5,330 is better than 1/5,000 - YES.

Step by Step Solution to #2 - Limits of Closure

2. Sec. 28 used a record bearing + distance.



STEP #1 CHANGE BR. + DIST. TO LAT. + DEP.



STEP #2 - Find ΣHD

79.90
79.80
80.00
+ 79.44
319.14 = Σ HD

STEP #3 - Find Misclosure in LAT.

(-0.40)
79.80
0.00
+ (-79.44)
-0.04 or S0.04

STEP #4 - CLOSURE IN LAT.

$\frac{319.14}{0.04} = 7,979$

STEP #5 - FIND MISCLOSURE IN DEP.

(-79.90)
0.00
80.00
(-0.18)
-0.08 or W 0.08

STEP #6 - CLOSURE IN DEP.

$\frac{319.14}{0.08} = 3,989$

STEP #7 - LAT. Within Limits?

1/7,979 is better than
1/2,500 - YES.

STEP #8 - DEP. Within Limits?

1/3,989 is better than
1/2,500 - YES.

STEP #9 - BR. + DIST. of Misclosure

S0.04 & W 0.08
S63-26-06 W
0.09

Appendix 2 - Standard Corner Numbering

Many of the proportion routines for rectangular corners in CMM are dependent upon or can perform more automated operations if the standard numbering system is used to identify the controlling or 'found' corners. Those of you familiar with the Bureau of Land Managements Geographic Coordinate Data Base (GCDB) Project will recognize similarities to their system. However the system in use within CMM is simpified and has some significant differences required to meet CMM requirements. *Some places in the documentation do refer to the system as the GCDB system.* Initially it was intended to make CMM independent of the corner identification system, as there are many effective rectangular corner identification systems that have been used throughout the years by different people and agencies. However the improved functionality that accrues in using a specific standard began to emerge as an important attribute. As a result at this point in the system development and use several programs make extensive use of the system:

AUTOPROP for example is dependent upon the system.

INREC's efficient record entry capabilities are only realised when using the standard numbering.

PROPORT is not dependent on the system however it is capable of making a better determination of the proper proportion method when the system is used.

ADJUST is independent of the system.

WHATIS's controlling corner tagging and **SECTSHOW**'s control corner depiction algorythms are dependent upon the system.

For more details see the Reference section documentation for the above programs.

The System

The system consists of a base 6 digit number. The first 3 digits, somewhat like an X coordinate represent corners on the N-S section lines, counting from the West boundary of a standard township. The second 3 digits, similar to a Y coordinate, represent corners located on the the E-W section lines counting from the south. Corners below the section corner level are indicated in approx. chain units i.e. counting from the West and South boundaries of the section. For example the 1/4 corner bet. 20 and 21 is: 300340.

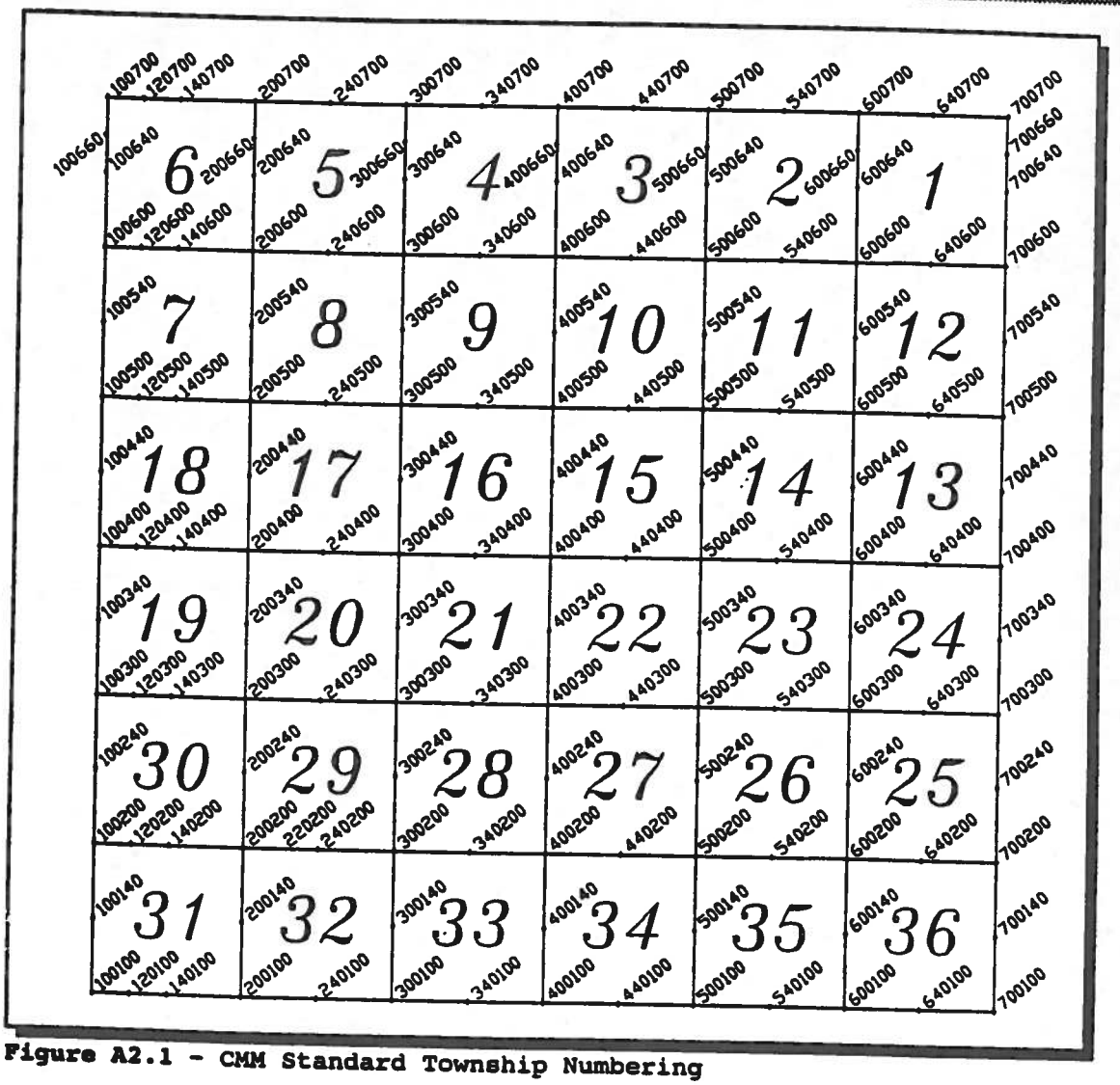


Figure A2.1 - CMM Standard Township Numbering

In the CMM standard system:

* Section corners are characterized by even x00y00 values, like 500300.

* Quarter Section corners are characterized by even 40 chain values like 500340, 540300 or 540340 which is the center 1/4 section corner of section 23.

* Sixteenth Section corners are characterized by even 20 chain values exclusive of the above. Values like 500320, 500360, 560300 (the East 1/16 corner between sections 23 and 26), and 520360 is the SE 1/16 corner of section 23.

* Corners below the 1/16 level are not necessary in the system, that is neither **PROPORT** or **AUTOPROP** compute corners at that level automatically.

* Creativity is required in extended sections. 1/16-80 corners can receive a 400680 designation, but sections elongated beyond 90 chains will require your imagination.

* Witness corners, meander corners, closing corners, etc. are designated at their approximate chain value in the system being careful to avoid EVEN chain increments. For example: a closing corner, CC, on the north boundary of the township that is offset 20 chains from the standard corners might logically be labelled 420700, but since this would indicate a 'regular' 1/16 section corner it should not be used. Instead 419700 or 421700 would be possible selections.

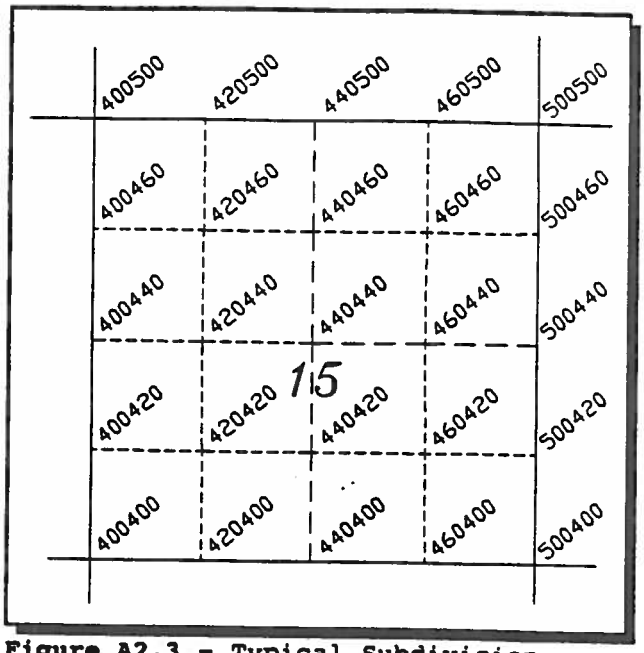


Figure A2.3 - Typical Subdivision Numbering

This is a departure from the GCDB system in at least two ways:

1) In CMM no particular rules are applied to these odd numbered corners, however GCDB rules that do not conflict with this system can be used.

2) Closing Corners and Standard Corners are designated according to their function in the PLSS rather that their role in the particular township. In GCDB the CC between sections 1 and 2 functions as a section corner and is designated 600700 for the township to the south, but it is not a section corner for the township to the north. In that townhip it would receive an 'odd' designation. In CMM this CC would receive the same first 3 digit designation for both townhips i.e. 617700 for the south township and 617100 in the north township. In CMM the function of the corner is determined by connectivity in .REC file.

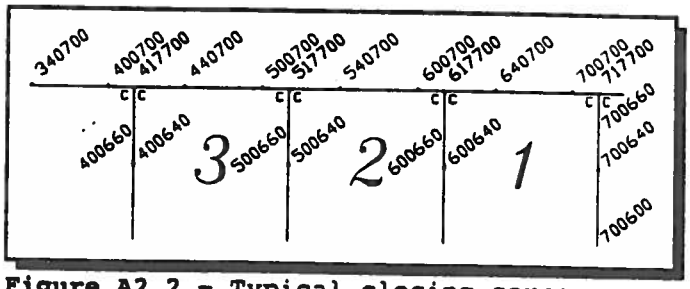


Figure A2.2 - Typical closing corner designation

The PLSS is very much more complex a system to be able to easily define rules to apply to all cases, user intuition and creativity will have to deal with unusual cases.