

HP-33S SURVEY and COGO PROGRAM

Detailed Instructions with example problems (and answers)

These detailed instructions (with example problems) can be used to get familiar with the program steps and can also be used to test the program to see if you entered the program code correctly.

Set the calculator's display to FIX 4. This will set the HP33S round off mode to 4 decimal places. To set this, turn on the HP33S and press the DISPLAY button on the right side just under the display screen. (It is one of the silver buttons just under the MODES button) Then press the 1 button and then you will see FIX_ on the screen. Now press 4 and your display will be set to 4 decimal places. You can set something other than 4 decimal places if you want, but I recommend at least 3 decimal because this will minimize round off error when you write down intermediate solutions and reuse them in future calculations.

XEQ 1 Storing Northing and Easting for Point 1

Actually this program is XEQ W but it is easier to find the 1 key.
Also, think of the 1 key as it relates to Point 1

For example, store the coordinates of N = 100 and E = 20
To do this, first key in 100 then press the ENTER key.
You will notice that both lines in the display show 100.0000.
Now key in 20 and then press XEQ 1 (the XEQ key and then the 1 key).
(when keying in the Easting don't press the ENTER key, press XEQ and the 1 keys)
The display will show the Northing 100.0000 on the top line and the
Easting of 20.0000 on the bottom line.
These N and E values will be stored as Point 1 to be used in future calculations.

XEQ 2 Storing Northing and Easting for Point 2

Actually this program is XEQ X but it is easier to find the 2 key.
Also, think of the 2 key as it relates to Point 2

For example, store the coordinates of N = 10 and E = 500
To do this, first key in 10 then press the ENTER key.
You will notice that both lines in the display show 10.0000.
Now key in 500 and then press XEQ 2 (the XEQ key and then the 2 key).
(when keying in the Easting don't press the ENTER key, press XEQ and the 2 keys)
The display will show the Northing 10.0000 on the top line and the
Easting of 500.0000 on the bottom line.
These N and E values will be stored as Point 2 to be used in future calculations.

XEQ 3 Inversing coordinates (Point 1 to Point 2)

Actually this program is XEQ Y but it is easier to find the 3 key.
After you have stored Points 1 and 2, press XEQ 3 and the top line on the display is the Distance from 1 to 2 and the bottom line on the display is the Azimuth from 1 to 2.
For the data entered above with XEQ 1 and XEQ 2 the distance is 488.3646 at the azimuth is 100-37-11. The azimuth will automatically display as DD.MMSS (Degrees.Minutes Seconds)

XEQ E Side Shot from Point 1

To find the Northing and Easting of a point that is a specific distance and direction from Point 1 (already stored with XEQ 1) first key in the distance and then press ENTER. Next key in the azimuth in the form of DD.MMSS and then press XEQ E. The Northing of this point will display on the top line and the Easting will display on the bottom line.

For example, (based on the above stored Points 1 and 2) to find the coordinates of a point that is 80.00 feet from Point 1 at a direction of S 09-15-00 E from Point 1. First key in 80 then press the ENTER key. Now key in the azimuth of 170.4500 and then press XEQ E.

The display will show the Northing of 21.0403 on the top line and the Easting of 32.8594 on the bottom line.

If you want to traverse from this new point to another point, you can do so by continuing with the Side Shot Program, but first you need to store this new coordinate as Point 1. This can be done by pressing XEQ 1 before doing anything else and this point will now become Point 1.

If you want to traverse with a side shot by turning a CW angle by backsighting along either line 1 to 2 or line 2 to 1, see the last program (XEQ O) in this instruction sheet.

XEQ B Bearing–Bearing Intersection

To find the Northing and Easting of the intersection of two lines with specified directions (azimuths) from points 1 and 2, first key in the Azimuth (as DD.MMSS) from Point 1 and the press ENTER. Next key in the Azimuth (as DDD.MMSS) from Point 2 and the press XEQ B. The Northing of this point will display on the top line and the Easting will display on the bottom line.

For example, (based on the above stored Points 1 and 2) if the direction from Point 1 is N 81-33-44 E then key in the Azimuth of 81.3344 and press ENTER. Next if the direction from Point 2 is N 15-00-00 W then key in the Azimuth of 345.0000 and press XEQ B.

The display will show the coordinates of the intersection point with a Northing of 165.0411 on the top line and an Easting of 458.4569 on the bottom line.

XEQ C Bearing–Distance Intersection

To find the coordinates of the intersections of both possible solutions of a line with a specified azimuth from Point 1 and a specified distance from Point 2, first key in the Azimuth (as DD.MMSS) from Point 1 and the press ENTER. Next key in the Distance from Point 2 and the press XEQ C. The Northing of this point will display on the top line and the Easting will display on the bottom line. Then press R/S to display the Northing and Easting of the second point. The Northing of this second point will display on the top line and the Easting will display on the bottom line.

For example, (based on the above stored Points 1 and 2) if the direction from Point 1 is S 85-11-22 E then key in the Azimuth of 94.4838 and press ENTER. Next if the distance from Point 2 is 123.45 then key in 123.45 and press XEQ C.

The display will show a Northing 49.7688 on the top line and an Easting of 616.8689 on the bottom line. Then Press R/S and the second solution point will show a Northing of 68.7420 on the top line and an Easting of 391.4215 on the bottom line.

XEQ D Distance–Distance Intersection

To find the coordinates of the intersection of a point that is a specified distance from Point 1 and a specified distance from Point 2, first key in the Distance from Point 1 and the press ENTER. Next key in the Distance from Point 2 and the press XEQ D. Since there are two possible solutions to a distance-distance intersection you must identify which side of Line 1 to 2 the intersection point is on. Press the + key if the intersection is to the Right of Line 1 to 2 or press the – key if the intersection is to the Left of Line 1 to 2. Then press the R/S key and the display will show the Northing on the top line and the Easting on the bottom line.

For example, (based on the above stored Points 1 and 2) if the distance from Point 1 is 400.00 feet then key in 400 and press ENTER. Next if the distance from Point 2 is 200.00 feet then key in 200 and press XEQ D.

Assume the intersection is Left of Line 1 to 2, so then press the – key and then the R/S key.

The display will show the coordinates of the intersection point with a Northing of 188.6341 on the top line and an Easting of 410.0564 on the bottom line.

To check the solution for the distance-distance intersection on the Right side of Line 1 to 2, key in 400 and press ENTER. Next key in 200 and press XEQ D. Since the point is on the right side of Line 1-2, then press the + key and then the R/S key.

The display will show a Northing –123.9171 on the top line and an Easting of 351.4530 on the bottom line

XEQ Z View Stored Coordinates (and Swap Coordinates)

To see what coordinates are stored as Point 1, press XEQ Z.

First the display will show the Point 1 Northing on the top line and the Easting on the bottom line.

Next, if desired, you may continue to see what coordinates are stored as Point 2. Press the R/S key. The display will now show the Point 2 Northing on the top line and the Easting on the bottom line.

Next, if desired, you may continue to swap the coordinates so they are stored as the other point number. In other words, The coordinates of Point 1 will now be stored as Point 2 and the Coordinates of Point 2 will now be stored as point 1. Press the R/S key to execute the swap.

The display will now show the new Point 1 Northing on the top line and the Easting on the bottom line.

For example, (based on the above original example Points 1 and 2) press XEQ Z and the display will show the Northing of 100.0000 on the top line and the Easting of 20.0000 on the bottom line.

Next press R/S and the display will show the Northing of 10.0000 on the top line and the Easting of 500.0000 on the bottom line.

Next press R/S and the coordinates will be swapped and the display will show the new Point 1 with the Northing of 10.0000 on the top line and the Easting of 500.0000 on the bottom line.

Note: The following programs are optional and not required to run basic COGO.

All or some of the following can be loaded depending upon if you have use for them.

Also, the remaining programs do not reference the COGO Points 1 and 2. Therefore you do not need to store points before running the following programs. In fact some of the following programs (while running) will may use the same storage registers and overwrite some of the values used for storing Points 1 and 2. So if after running some of the following programs and then you go back to run some of the above COGO programs, you will want to either re-enter the values for Points 1 and 2 or do an XEQ Z to view and verify that the point values for Points 1 and 2 are still stored and correct.

For general information, the Northing and Easting values of Points 1 and 2 are stored in the following storage registers. Without using XEQ 1 or XEQ 2 you can store or recall the values individually as indicated below.

Point 1 Northing	=	STO T (the 4 key)	to view do a RCL T (the 4 key)
Point 1 Easting	=	STO W (the 1 key)	to view do a RCL W (the 1 key)
Point 2 Northing	=	STO U (the 5 key)	to view do a RCL U (the 5 key)
Point 2 Easting	=	STO X (the 2 key)	to view do a RCL X (the 2 key)

Also, all of the following programs are optional and need not be loaded to run any of the COGO solutions discussed above.

XEQ A Area by Coordinates

This program will compute the area of a boundary defined by straight lines (a polygon). To compute this area, arbitrarily select a starting point and key in its Northing value and then press ENTER. Then key in the Easting value for this point and press XEQ A. Continue by going around the figure (either clockwise or counter clockwise) entering the Northing value followed by the ENTER key and then the Easting value followed by the R/S key. Continue entering coordinates this way until you return to the starting point (each time pressing ENTER after the Northing and pressing R/S after the Easting). Be sure to end at the starting point. In other words enter the Northing and Easting values of the starting point just like all the other points. The numbers that show on the display after each Enter or R/S mean nothing until the very last R/S key is pressed after the easting of the starting (or closing) point. At that time the top value in the display will show the area in square feet and the bottom value in the display will show the area in acres.

The program is limited to a maximum 7 sided polygon (defined by a maximum of 8 points). If you have a larger polygon, then split it into parts and sum the smaller areas for the total.

For example, key in these coordinates to find the area within its boundary.

100	Enter	100	XEQ A
100	Enter	500	R/S
800	Enter	700	R/S
900	Enter	100	R/S
100	Enter	100	R/S

The top line on the display will show 380,000.0000 SF and the bottom line 8.7236 Acres

XEQ 5 Interpolation (and Extrapolation)

Actually this program is XEQ U but it is easier to find the 5 key.
Also, think of the 5 key as it relates the data stored in the 2 and 8 keys

In this program, if you know two points on a line (each point defined by X and Y coordinates) then you can find any point on that line if you know only one of the X or Y values on the same line. For example, if you know 2 points on a grade, line like Station and Elevation, then you can find the elevation of another point on the same grade line if you know the station of that point. Store the known X values in the 1 and 7 registers and store the known Y values in the 8 and 2 registers. Store the known X in the 4 register and press XEQ 5 to solve for the unknown Y value.

Store your data in the following format:

<u>X</u>	<u>Y</u>	
STO 7	STO 8	Upper coordinate limit
STO 4	[]	← Press XEQ 5 to find the value that goes between the stored limits
STO 1	STO 2	Lower coordinate limit

For example, to find the elevation at station 22+33.44 if the following points on a constant grade line are known:

Station	Elevation
21+00	456.78
24+50	472.11

Store the above data in the following storage registers:

2100 STO 7	456.78 STO 8	Note: When using station values in the program, just omit the + sign. For example Station 22+33.44 is 2233.44
2233.44 STO 4		
2450 STO 1	472.11 STO 2	

Now press XEQ 5 and both the top and bottom displays will show the answer of 462.6247 which in this example is the elevation.

XEQ V Vertical Curve Program

To compute the elevations of points on a vertical curve store the following values in the required storage registers and then press XEQ V. The display will give the station of each curve point on the top line and the elevation on the bottom line.

For example: If you want the elevations at each ½ station (50 feet) on a 200 foot long vertical curve that has its PVI at 20+20 with an elevation of 345.00 and Grade 1 = +4.00% and Grade 2 = -2.00% store these values in the following registers:

2020	STO A	PVI station
345.0	STO B	PVI elevation
4.0	STO C	Grade 1
-2.0	STO D	Grade 2
200	STO E	Length of VC
50	STO F	Station increment

Press XEQ V and the output display will show these values. The station is on the top line and the elevation is on the bottom line.

<u>Station</u>	<u>Elevation</u>	<u>Key</u>	
1920	341.0000	R/S	(PVC of the Vertical Curve)
1950	342.0650	R/S	
2000	343.2400	R/S	
2050	343.6650	R/S	
2100	343.3400	R/S	
2120	343.0000	R/S	(PVT of the Vertical Curve)

(If you press one or more R/S keys after the PVT the numbers displayed will be meaningless. If you do not have program XEQ U loaded then you will get a message of NON EXISTENT if you hit one more R/S keys after the PVT is displayed. If you see NON EXISTENT in the display just press the C key to get back to the normal display mode)

XEQ H Vertical Curve (High or Low Point)

To compute the elevation of the high or low point on a vertical curve, first store all the vertical curve data shown in the above XEQ V program. Then run the XEQ V program (hitting all of the R/S's are optional and not necessary if all the curve station and elevations are not needed) Then press XEQ H and the top line will display the high or low point station and the bottom line will display the high or low point elevation.

For example if you just ran the XEQ V program with all of the vertical curve data stored in the above example, press XEQ H and the top line will display a station of 2053.3333 and the bottom line will display the elevation of 343.6667.

XEQ P Vertical Curve (Elevation at any Station)

To compute the elevation of any point on the vertical curve, first store all the vertical curve data shown in the above XEQ V program. Then run the XEQ V program (hitting all of the R/S's are optional and not necessary if all the curve station and elevations are not needed) Then key in the station value of the desired point and press XEQ P. The top line will display the station and the bottom line will display the elevation of this point.

For example if you just ran the XEQ V program with all of the vertical curve data stored in the above example, and you want to know the elevation of Station 19+65.43 then key in 1965.43 and press XEQ P. The top line will display the station of 1965.4300 and the bottom line will display the elevation of 342.5076.

XEQ J Horizontal Curve Solutions (when the Central Angle and the Radius are known)

To compute several Horizontal Curve components (when the Central Angle and Radius are known) first key in the Central Angle in the form of DD.MMSS and then press ENTER. Next key in the Radius and press XEQ J. The following curve components will display in this order:

Top line	Central Angle		
Bottom line	Radius	R/S	All R/S's are optional
Top line	Arc Length		if the following answers
Bottom line	Tangent Length	R/S	are not needed.
Top line	Chord		
Bottom line	Degree of Curvature (arc definition)	R/S	
Top line	External		
Bottom line	Mid Ordinate	R/S	
Top line	Sector area in SF		
Bottom line	Arc to Chord area in SF		

For example: If you want to solve for the horizontal curve components for a curve that has a Central Angle of 45-10-50 and a Radius of 450 feet then first key in the Central Angle of 45.1050 and press ENTER, then key in the Radius of 450 and press XEQ J. The following answers will display with R/S's in between display sets.

Top line	45.1050	Central Angle in DD.MMSS format	
Bottom line	450.0000	Radius	R/S
Top line	354.8473	Arc Length	
Bottom line	187.2273	Tangent Length	R/S
Top line	345.7248	Chord	
Bottom line	12.4357	Degree of Curvature (arc definition)	R/S
Top line	37.3952	External	
Bottom line	34.5261	Mid Ordinate	R/S
Top line	79,840.6320	Sector area in SF	
Bottom line	8,020.8112	Arc to Chord area in SF	

XEQ K Horizontal Curve Solutions (when the Central Angle and Arc Length are known)

To compute several Horizontal Curve components (when the Central Angle and Arc Length are known) first key in the Central Angle in the form of DDD.MMSS and then press ENTER. Next key in the Arc Length and press XEQ K. The following curve components will display in the same order as in the above XEQ J program:

For example: If you want to solve for the horizontal curve components for a curve that has a Central Angle of 45-10-50 and an Arc Length of 354.84725354 then first key in the central angle of 45.1050 and press ENTER, then key in the Arc Length of 354.84725354 and press XEQ K. The answers will display with R/S's in between display sets and they will be the same answers as in the above example for the XEQ J program.

XEQ L Horizontal Curve Solutions (when the Radius and Arc Length are known)

To compute several Horizontal Curve components (when the Radius and Arc Length are known) first key in the Radius and then press ENTER. Next key in the Arc Length and press XEQ L. The following curve components will display in the same order as in the above XEQ J program:

For example: If you want to solve for the horizontal curve components for a curve that has a Radius of 450 and an Arc Length of 354.84725354 then first key in the Radius of 450 and press ENTER, then key in the Arc Length of 354.84725354 and press XEQ L. The answers will display with R/S's in between display sets and they will be the same answers as in the above example for the XEQ J program.

XEQ F Station and Offset solution

With this program you will be able to determine the station and offset of any point with known N and E coordinates. This station and offset will be determined from a base line (that is defined by two known coordinates N and E). First store the base line points as Point 1 and Point 2 with the programs **XEQ 1** and **XEQ 2** (defined on page 1 of these instructions). Point 1 is where the station line begins at 0+00 and Point 2 defines the direction of the base line in which the stationing is to be measured along and where the offsets are to be measured from. Then key in the Northing of the point you wish to locate by station and offset and then press **ENTER**. Then key in the Easting of this point and press **XEQ F**. The top line of the display is the station (without the + sign) and the bottom line is the offset distance as measured perpendicular from the baseline. Positive offsets are Right of the baseline (as defined from Point 1 to Point 2) and Negative offsets are Left of the baseline. A Negative station value indicates the perpendicular offset to the baseline occurs before station 0+00.

If your Point 1 already has a station value (other than 0+00), then add it to the stationing solution from this program.

For example: If a base line starts at station 30+00 (which is located at N=100 and E=20) and it continues to another point (which is located at N=10 and E=500) then use XEQ 1 and XEQ 2 to store these two points. (Storing Points 1 and 2 are given on page 1 of these instructions). If a point off to the side of this base line has the of coordinates of N=55, E=300 the you can determine its station and offset by keying in 55 and pressing **ENTER** and then keying in 300 and pressing **XEQ F**. On the top line of the display the station value of 283.4972 and the offset value of -7.3715 will show. The station value is the distance from Point 1 so the actual station would then be 30+00 plus 283.4972 or 32+83.4972. The offset distance of -7.3715 means the point is 7.3715 left of the baseline as defined from Point 1 to Point 2

The program will remember Points 1 and 2 so you can repeat entering points and then pressing **XEQ F** to find the station and offset of other points.

XEQ I Stake out a point

If you know the coordinates of a point you wish to stake, then this program will give you the angle and distance to that point from the occupied point and a backsight point. First store the coordinates of the two known reference points, the occupied point in **XEQ 1** and the backsight point in **XEQ 2**. Then input the Northing of the stake out point and press **ENTER** then input the Easting of the stake out point and press **XEQ I**. The top number in the display is the distance from the occupied point (Point 1) to the stake out point and the bottom number in the display is the angle right (or CW angle) from the backsight (Point 2) to the stakeout point.

For example if the occupied point is the same point as Point 1 in the previous example located at N=100 and E=20 and Point 2 (the backsight point) the same as Point 2 in the previous example located at N=10 and E=500, use XEQ 1 and XEQ 2 as before, to store these two points. With the instrument set up on Point 1 you backsight point 2 and set zero on the circle. Now to stake out a point with the coordinates of N = 300 and E = 600 first key in the Northing 300 and press **ENTER** and then key in the Easting 600 and press **XEQ I**. The top line in the display is the distance to the stake out point 613.5145 and the second line is the CW angle of 330-21-17 to the stake out point

The program will remember Points 1 and 2 so you can repeat entering stake out points and then by pressing **XEQ I** each time you can stake out any number of points from this occupied point.

XEQ O (not zero) Side Shot Solution (with an Angle and Distance from a Backsight Line)

With this program you will be able to determine the Northing and Easting of a point if you know the distance and clockwise angle from a reference line (backsight line). First store the coordinates of the two points on the reference line (backsight line) in XEQ 1 and XEQ 2 (the point stored in XEQ 1 is where the instrument is setup, also this is where the distance is measured from to the side shot point. The point stored in XEQ 2 is the backsight point, this is where you would zero out the instrument before turning the clockwise angle to the side shot point) (CCW angles can be entered as negative)

For example if the reference line is the same line as the baseline in the previous example where Point 1 is located at N=100 and E=20 and Point 2 is located at N=10 and E=500, use XEQ 1 and XEQ 2 as before, to store these two points. Assume the instrument is set up on Point 1 and you backsight point 2 and set zero on the circle. After you measure a distance of 44.44 to the side shot point, key in 44.44 and press ENTER. After you measure the clockwise angle of 12-34-56 to the side shot point, key in 12.3456 and press XEQ O.

The display will show the coordinates of the side shot point with a Northing of 82.4919 on the top line and an Easting of 60.8458 on the bottom line.

XEQ O (not zero) Traverse with Side Shot (with an Angle and Distance from a Backsight Line)

Same as the last described program except that with one extra step while running the above program you can traverse to the side shot (foresight) point. In other words, once you determine the Northing and Easting of the foresight point with XEQ O and its Northing and Easting shows in the display, you can move up to that point by hitting the R/S key. The just solved for foresight point will now become Point 1 and the previous instrument location will become Point 2 (the backsight point).

For example if you just completed the example above and now plan to move the instrument to that point to continue traversing first press R/S. Now you backsight to the previous point 1 in the last example and you set zero on the circle. Then you measure a distance of 59.21 and a CW angle of 315-51-22 to the new foresight point. First key in 59.21 and press **ENTER**, then key in the angle of 315.5122 and press **XEQ O**. The display will show the coordinates of this new foresight point with a Northing of 61.3289 on the top line and an Easting of 5.5471 on the bottom line.

This process can be repeated each time you plan to move the instrument. If you want to take some side shots along the way without advancing the instrument to the next point, just enter new distances and angles like you would with XEQ O but without hitting R/S after the Northing and Easting show in the display. Only hit R/S after you do an XEQ O when you are advancing to the foresight point.