

# GeoEasy 3 Step by Step Tutorial

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## Note

This training material does not extend to the use of the program in every detail, further information can be found in other documentation files.

The installation kit contains a *demodata* directory. In this guide the data files from the *demodata* directory will be used.

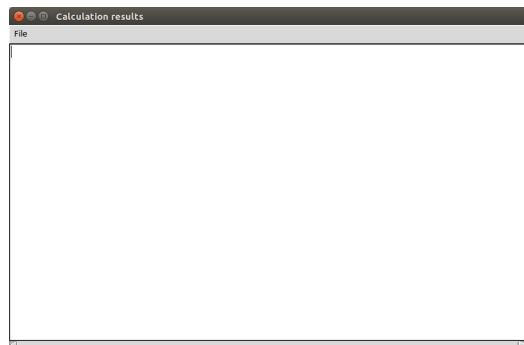
Images in this tutorial are generated on an Ubuntu box. Window layouts on different operating systems may look different.

After starting GeoEasy a small windows appears near to the upper left corner of your monitor. It is the main window with a menu and a rotating Earth. If the rotation stopped the software is busy, user have to wait.



*Main window*

Another window is opened for the calculation results. It has dual function besides the results it has some logging role.



*Calculation results window*

## Loading sample data set

In the main window select **File/Load...** from the menu. Navigate to the *demodata* folder and select *test1.geo*. A log message appears in the *Calculation results* window, that data have been loaded.

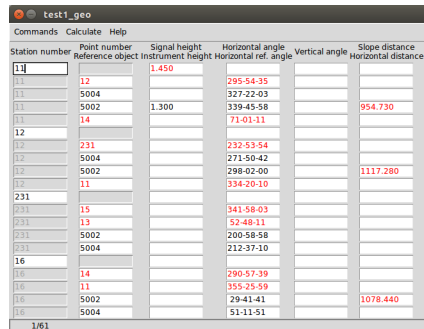
## View and edit field-books

The loaded field-books can be opened in a window. Select **Edit/Observation** from the menu of the main window. In a cascading menu the name of the loaded data sets popup, in this case only *test1* is visible, select it. Field-book data are displayed in the default mask type.

## GeoEasy Step by Step

### Note

The mask name is used for dialog boxes containing tabular data. This comes from the display masks which were used on old Leica instruments.



The screenshot shows a window titled 'test1\_geo' with a menu bar (Commands, Calculate, Help) and a table of fieldbook data. The table has columns for Station number, Point number, Reference object, Signal height, Instrument height, Horizontal angle, Horizontal ref. angle, Vertical angle, Slope distance, and Horizontal distance. Data is entered for various stations, with some values highlighted in red.

Station number	Point number	Reference object	Signal height	Instrument height	Horizontal angle	Horizontal ref. angle	Vertical angle	Slope distance	Horizontal distance
11	12		1.450		295-54-35				
11	5004				327-22-03				
11	5002	1.300			339-45-58			954.730	
11	14				71-01-11				
12	231				232-53-54				
12	5004				271-50-42				
12	5002				298-02-00			1117.280	
12	11				334-20-10				
231	15				341-58-03				
231	13				52-48-11				
231	5002				200-58-58				
231	5004				212-37-10				
16	14				290-57-39				
16	11				355-25-59				
16	5002				29-41-41			1078.440	
16	5004				51-11-51				

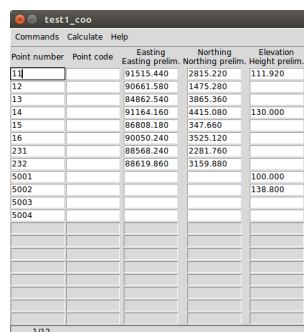
Fieldbook data

Data are arranged in a table, a row contains station or observed point data. Column header can contain more labels (e.g. Signal height and Instrument height). The color of the values in the cells can be different, if more header lines are present, for example signal heights are black, instrument heights are red. Colors can be customized in the **File/Colors...** menu from the main window.

You can move in the table using the right side scroll bar, up and down arrow keys, mouse wheel (Windows only), TAB/PgUp/PgDn/Ctrl-PgUp/Ctrl-PgDn keys. You can edit the content of the active field, inside the field Home/End/Backspace/Delete/Insert keys can be used. If the edited value is not valid (e.g. non-numeric value in the distance field) an error message appear and you can not leave the field until the field value is invalid.

## View and edit coordinate lists

The loaded coordinate lists can also be opened in a window. Select **Edit/Coordinates** from the menu of the main window. In a cascading menu the name of the loaded data sets popup, in this case only *test1* is visible, select it. Coordinate data are displayed in the default mask type. Points are ordered in the table by point IDs.



The screenshot shows a window titled 'test1\_coo' with a menu bar (Commands, Calculate, Help) and a table of coordinate data. The table has columns for Point number, Point code, Easting, Easting prelim., Northing, Northing prelim., and Elevation. Data is entered for various points, with preliminary values highlighted in red.

Point number	Point code	Easting	Easting prelim.	Northing	Northing prelim.	Elevation
11		91515.440		2815.220		111.920
12		90661.580		1475.280		
13		84862.540		3865.360		
14		91164.160		4415.080		130.000
15		86808.180		347.660		
16		90050.240		3525.120		
231		88568.240		2281.760		
232		88619.860		3159.880		
5001						100.000
5002						138.800
5003						
5004						

Coordinate data

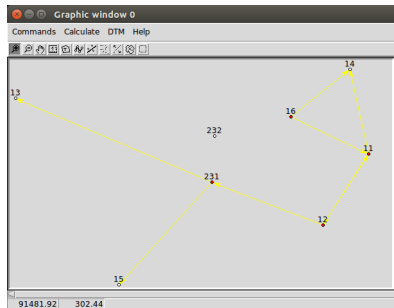
Data are arranged in a table, a row contains coordinates of a point. Column header can contain more labels (e.g. Easting and Easting prelim.) The color of the values in the cells can be different, eastings are black, preliminary eastings are red. Colors can be customized in the **File/Colors...** menu from the main window.

## GeoEasy Step by Step

Field values can be edited in the same way as in field-books. The default mask for field-books and coordinate lists can be configured in the *geo\_easy.msk* file (*geoMaskDefault* and *cooMaskDefault* variables)

## Graphic window

Points having horizontal coordinates from all loaded data sets are displayed in graphic window. Select **Window/New graphic window** from the menu of the main window or press F11 key to open a new graphic window.



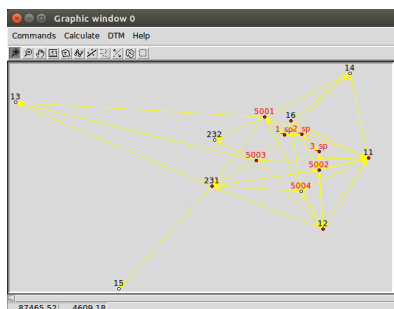
*Graphic window*

Enlarge the size of the graphic window, drag the corner of the window by the mouse and press F3 to zoom to extent. Point symbols, IDs and observations are visible in the graphic window. Red filled circles are stations but not oriented yet.

## Preliminary coordinates

Let's calculate preliminary coordinates for those points which have no coordinates so far. Select **Calculate/Preliminary coordinates** from the menu of any window. You'll get a message, that there are no elevations for some points. Several points will be added to the graphic window and the coordinate list. They have red point IDs to mark preliminary coordinates. Preliminary orientations and elevations are also calculated.

Press F5 button to turn off detail points, having a less crowded view in the graphic window (or **Commands/Detail points** from the menu of the graphic window).



*Graphic window detail points turned out*

### Note

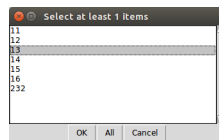
Detail points are selected by the program using the following rules. A detail point has a numeric ID and has only one polar observation and was not station.

## Calculations

The calculation results are listed in the *Calculation results* window, if you have closed it, open it **Window/Log window** from the menu of the main window. Calculation results are stored in a log file (*geo\_easy.log* in the user's home directory), so you can review them later. There are calculations for a single point and multiple points. Single point calculations are available from the popup menu, right click on the point in the graphic window or in the row of the point in the coordinate list window or in the field-book window. Multi point calculations are available from the *Calculation\** menu of any window.

### Whole circle bearing and distance

Let's calculate the whole circle bearing and distance between points 231 and 13. Click on the point 231 with the right mouse button in the graphic window and select **Bearing/Distance** from the popup menu. A selection list is displayed with the point IDs having coordinates. You can select one or more point to calculate bearing and distance. Select 13 from the list. The calculation result is visible in the *Calculation results* window and in the status bar of the graphic window.



*Point selection box*

```
2017.11.26 09:22 - Bearing/Distance
Point num  Point num  Bearing  Distance Slope dis Zenith angle
231         13        293-08-21 4029.889
```

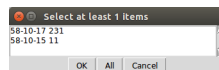
The slope distance and the zenith angle are calculated only if the elevations of the points are known.

### Note

You can use the right mouse button in the field-book or coordinate list windows, too. Right click on the point ID and select **Calculate**, a cascading menu appears with the possible calculations for the point. If you select the menu item with the point ID an info box will be displayed about the point.

### Orientation on a station

Let's calculate orientation for station 12. Click on the point 12 with the right mouse button in the graphic window. Select **Orientation** from the popup window. A list with the back-sight directions are displayed, orientation angle in the first column and point ID in the second.



*Backsight selection*

Select both points (231, 11), use Shift or/and Ctrl keys to select more lines. If you would like to select all rows, click on the *All* button.

A weighted average will be calculated for the mean orientation angle, the weights are the distances. The calculation results are shown in the *Calculation results* window.

## GeoEasy Step by Step

2017.11.26 09:47 - Orientation - 12

Point num	Code	Direction	Bearing	Orient ang	Distance	e"	e"max	E(m)
231		232-53-54	291-04-11	58-10-17	2243.319	0	16	0.010
11		334-20-10	32-30-25	58-10-15	1588.873	-1	19	-0.010
Average orientation angle				58-10-16				

The  $e''$  column contains the difference from the mean,  $e''(max)$  is the allowable maximal difference (depending on distance),  $E(m)$  is the linear difference at the back-sight point.

Note that the fill color of the point marker of point 12 became green, oriented station. The orientation angles and the mean are stored in the field-book, too. Select the orientation mask from the **Commands/Mask...** in the field-book window to see them.

## Orientation for all points

You can calculate orientations for all station in a single step, select **Calculate/Orientations** from the menu of any window. Results are written to the *Calculation results* window. If the difference from the mean is too large a warning is displayed. The three other unoriented stations are also oriented.

2017.11.26 10:05 - Orientation - 11

Point num	Code	Direction	Bearing	Orient ang	Distance	e"	e"max	E(m)
12		295-54-35	212-30-25	276-35-50	1588.873	1	19	0.010
14		71-01-11	347-36-58	276-35-47	1637.971	-1	18	-0.010
Average orientation angle				276-35-48				

2017.11.26 10:05 - Orientation - 231

Point num	Code	Direction	Bearing	Orient ang	Distance	e"	e"max	E(m)
15		341-58-03	222-18-10	240-20-07	2615.063	-1	14	-0.023
13		52-48-11	293-08-21	240-20-10	4029.889	1	11	0.023
Average orientation angle				240-20-08				

2017.11.26 10:05 - Orientation - 16

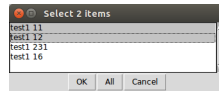
Point num	Code	Direction	Bearing	Orient ang	Distance	e"	e"max	E(m)
14		290-57-39	51-22-38	120-24-59	1425.779	-2	20	-0.016
11		355-25-59	115-51-02	120-25-03	1628.118	2	18	0.016
Average orientation angle				120-25-01				

### Note

Orientation angles are stored in the field-book, you can see them if you select *orientation* template (mask). The calculated orientation angles will overwrite the previous values.

## Intersection

Let's calculate the coordinates of point *5004* using intersection. Four directions were measured from point *11*, *12*, *231* and *16* to *5004*. Stations have to be oriented to be used in intersection. Right mouse button click on point *5004* in the graphic window and select **Intersection** from the popup menu. A list of possible intersection directions are displayed in the selection window. The field-book name and the point numbers are shown in the list (if more field-books are loaded, stations from any field-book can be used). Select two directions *11* and *12* (best intersection angle).



*Intersection point selection*

There are two columns in the list window. The first column refers to the data set name, the second column contains point numbers.

### Note

This selection dialog is used at several places in the user interface. Check the header of the selection window, how many lines should be selected.

2017.11.26 10:23 - Intersection

Point num	Code	E	N	Bearing
11		91515.440	2815.220	243-57-51
12		90661.580	1475.280	330-00-58
5004		90246.207	2195.193	

Note the color of point number is changed in the graphic window from red to black after calculation done.

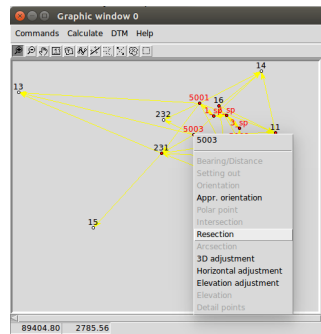
### Note

You can repeat the intersection calculation selecting different directions. The last calculated coordinates are stored only in the coordinate list. Previous coordinates will be overwritten.

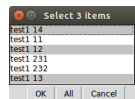
## Resection

Let's calculate the coordinates of point *5003* in demo data set using resection. There are six possible directions for resection. Let's find the best geometry, 120 degree between directions at 5003. Point *12*, *13* and *14* look optimal. Right mouse button click on point *5003* in the graphic window and select **Resection** from the popup menu. A list of possible resection directions are displayed in the selection window. The field-book name and the point numbers are shown in the list.

## GeoEasy Step by Step



*Resection from the popup menu*



*Resection point selection*

2018.01.20 11:26 - Resection

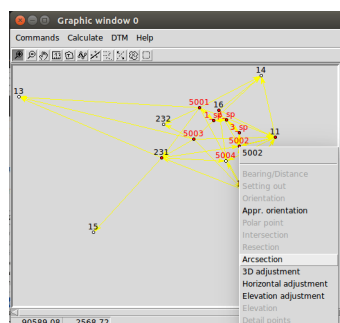
Point num	Code	E	N	Direction	Angle
14		91164.160	4415.080	99-10-24	88-42-37
12		90661.580	1475.280	187-53-01	147-41-20
13		84862.540	3865.360	335-34-21	
5003		89398.550	2775.210		

### Note

You can repeat the resection calculation selecting different direction. The last calculated coordinates are stored only in the coordinate list. Previous coordinates will be overwritten.

## Arcsection

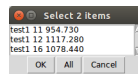
Let's calculate the coordinates of point 5002 using arcsection. There are three measured distances from 5002 to 11, 12 and 16. Right mouse button click on point 5003 in the graphic window and select **Arcsection** from the popup menu. A list of possible arcsection directions are displayed in the selection window. The field-book name and the point numbers are shown in the list.



*Arcsection from the popup menu*

Let's use the distance from point 11 and 12.

## GeoEasy Step by Step



### *Arcsection point selection*

2018.01.20 12:01 - Arcsection

Point num	Code	E	N	Distance
11		91515.440	2815.220	954.730
12		90661.580	1475.280	1117.280
5002		90587.628	2590.110	

### **Note**

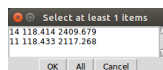
Using arcsection there are two solution (two intersections of the two circles). If there are more observations for the point to be calculated, GeoEasy can choose the right solution as this case a third distance. Otherwise the user have to select from the two possible solutions.

### **Note**

You can repeat the arcsection calculation selecting different distances. The last calculated coordinates are stored only in the coordinate list. Previous coordinates will be overwritten.

## Elevation calculation

Let's calculate the elevation of point 5003. Right mouse button click on point 5003 in the graphic window and select **Elevation** from the popup menu. A list of possible elevation calculations are displayed in the selection window. The point name, the elevation and the distance are shown in the list.



### *Elevation point selection*

Let's select both rows. The elevation will be calculated as a weighted average. The weight is inverse proportional of the distance square.

2018.01.20 20:30 - Elevation

Point num	Code	Height	Distance
14		118.414	2409.679
11		118.433	2117.268
5003		118.425	

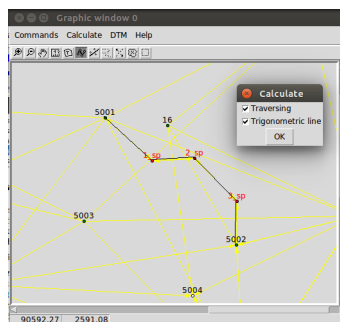


**Note**

You can repeat the elevation calculation selecting different points. The last calculated elevation is stored only in the coordinate list. Previous elevation will be overwritten.

**Traverse and trigonometric line**

There is a traversing line with three internal points (1\_sp, 2\_sp, 3\_sp) between point 5001 and 5002. Let's use the 6th toolbar icon to specify the traversing line. Click on the first point (5001) and the three internal points using the traversing tool and double click on the last point (5002). A black line is drawn as you click on points.



*Traversing line selection*

This is an open traversing with orientation on both known endpoints. A small dialog is shown where you can select the calculation task. Traversing to calculate horizontal coordinates and/or Trigonometric line to calculate elevations.

2018.01.20 21:11 - Traversing Open, two orientation

Point	bearing angle	bw dist distance	(dE)	(dN)	dE Easting	dN Northing
	correction	fw dist	corrections			
	0-00-00	-				
5001	132-34-52					
	- 0-00-05				89562.512	3587.544
	132-34-47	-				
1_sp	134-23-17	498.890	367.351	-337.557	367.369	-337.521
	- 0-00-05	-	0.018	0.035	89929.881	3250.023
	86-57-59	-				
2_sp	228-16-31	330.610	330.147	17.496	330.159	17.520
	- 0-00-05	-	0.012	0.023	90260.040	3267.542
	135-14-25	-				
3_sp	225-08-37	468.460	329.859	-332.637	329.876	-332.604
	- 0-00-06	-	0.017	0.033	90589.916	2934.938
	180-22-56	-				
5002	359-37-10	344.860	-2.301	-344.852	-2.288	-344.828
	- 0-00-06	-	0.012	0.024	90587.628	2590.110
	0-00-00				1025.116	-997.434
	1080-00-27	1642.820	1025.056	-997.550		
	720-00-00					
	- 0-00-27		0.060	0.116		

## GeoEasy Step by Step

0.130

Error limits	Angle (sec)	Distance (cm)
Main, precise traversing	50	30
Precise traversing	65	38
Main traversing	67	51
Traversing	85	63
Rural main traversing	87	71
Rural traversing	105	89

2018.01.20 21:11 - Trigonometrical line

Point	Distance	Forward	Backward	Height differences		
				Mean	Correction	Elevation
5001						100.000
	498.879	23.947	-	23.947	-0.010	
1_sp						123.938
	330.623	0.307	-	0.307	-0.004	
2_sp						124.240
	468.449	12.661	-	12.661	-0.008	
3_sp						136.893
	344.836	1.926	-	1.926	-0.005	
5002						138.815
	1642.787			38.842	-0.027	38.815

Error limit: 0.118

### Note

Orientations on all stations were calculated previously. Orientation have to be calculated before traversing calculation.

You can start traversing calculation from the **Calculation/Traversing** menu. That case the traversing points are selected from lists.

## Detail points

Some polar detail points were measured from the traversing points. Let's calculate the coordinates for those points. The fastest way to get the coordinates of detail points is to select **Calculation/New detail points** from the menu. It will calculate orientation angle automatically if necessary.

2018.01.28 13:30 - New detail points

Point num	Code	E	N	H	Station	Oriented direction	Horizontal distance
101		89817.597	3124.363	125.301	1_sp	221-46-38	168.468
102		89888.171	3112.673	126.819	1_sp	196-52-41	143.505
103		90043.330	3181.366	126.988	1_sp	121-09-42	132.631
201		90257.647	3134.405	124.353	2_sp	181-00-54	133.142
202		90112.941	3206.373	120.740	2_sp	247-25-17	159.272

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301	90543.529	2842.469	139.235	3_sp	206-38-02	103.440
302	90467.005	2904.622	137.424	3_sp	256-08-41	126.578
303	90443.170	2958.505	139.836	3_sp	279-07-35	148.611

### Note

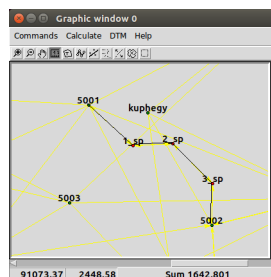
You can recalculate all detail points after editing the observation data using **Calculate/All detailpoints**, you may need to recalculate orientation, too. You can recalculate station by station, right click in the graphic window on a station and select **Detail points** from the popup menu.

## Calculation distances and areas

The sum of the horizontal distances between points having coordinates can be calculated in the graphic window using the ruler tool from the toolbar (4th icon). Click on the point marker of the first point and the further points. Finally double click on the last point. A report is sent to *Calculation results* window.

2018.02.24 09:11 - Distance calculation			
Point num	E	N	Length
5001	89562.447	3587.503	
1_sp	89929.837	3249.997	498.885
2_sp	90260.005	3267.527	330.633
3_sp	90589.899	2934.934	468.453
5002	90587.624	2590.112	344.830
Sum			1642.801

The sum of the distances is shown in the status line of the graphic window, too.



Distance calculation

The next icon, right to the distance calculation is the area calculation. It works similar to the distance calculation. Click on the points of the polygon and double click on the last point (you needn't to click on the first point finally). The calculation result are reported in the *Calculation result* window.

2018.02.24 09:18 - Area calculation			
Point num	E	N	Length
5003	89398.545	2775.181	
5001	89562.447	3587.503	828.693
1_sp	89929.837	3249.997	498.885
2_sp	90260.005	3267.527	330.633
3_sp	90589.899	2934.934	468.453

## GeoEasy Step by Step

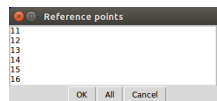
5002	90587.624	2590.112	344.830
5003	89398.545	2775.181	1203.396
Area	680295.78817		
Perimeter	3674.889		

### Note

The distance and area calculation is available from the **Calculation** menu. That case the points are selected from lists.

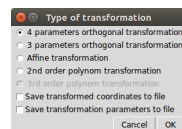
## Coordinate transformation

During a GeoEasy session all points have to be in the same coordinate reference system (CRS). Coordinates can be converted between two CRSs if there are common points in the two system. Two GeoEasy data sets have to be used. The source data set is opened and select **Calculation/Coordinate transformation** from the menu. The target data set have to be selected next. Select *test1\_trafo.geo* from the *demodata* folder. A list of the common points width horizontal coordinates in the two data sets is shown.



### Common points for transformation

Select all points and press OK button. In the next dialog box the transformation type can be selected.



### Transformation options

Pressing the OK button the transformation parameters are calculated using the least squares method. In the *Calculation results* window three blocks of information is displayed.

```
2018.02.24 12:09 - 4 parameters orthogonal transformation test1 -> test_trafo
E = 561684.477 + e * 0.999997669 - n * -0.000003434
N = 246411.178 + e * -0.000003434 + n * 0.999997669

Scale = 0.99999767 Rotation = - 0-00-01

Point num      e          n          E          N          dE          dN          dist
11             91515.440      2815.220      653199.720      249226.070      -0.007       0.007       0.010
12             90661.580      1475.280      652345.850      247886.150       0.001      -0.007       0.007
13             84862.540      3865.360      646546.830      250276.240       0.002      -0.003       0.004
14             91164.160      4415.080      652848.440      250825.940      -0.001      -0.006       0.006
15             86808.180       347.660      648492.460      246758.540      -0.004      -0.001       0.005
16             90050.240      3525.120      651734.510      249935.970       0.009       0.010       0.014
```

## GeoEasy Step by Step

RMS= 0.008

Point num	e	n	E	N
231	88568.240	2281.760	650252.518	248692.628
232	88619.860	3159.880	650304.141	249570.746

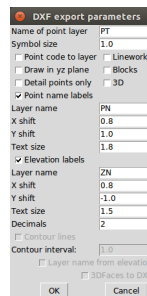
In the first block the formula of the transformation is given. The second block contains the coordinates of common points and the errors. In the third block the transformed coordinates are given, those points can be found here which have coordinates in the source data set but not in the target data set.

### Note

If the transformation parameters are known use the **Commands/Transformation** or **Commands/Transformation, parameters from file** from the menu of the coordinate list window.

## Save to DXF file

The points with horizontal coordinates from all loaded data sets can be exported into a DXF file. Select **Commands/DXF output** from the menu of the graphic window. In the displayed dialog box several options can be set for the DXF file.



*DXF options*

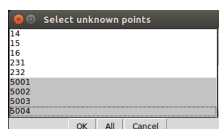
The point symbol (AutoCAD point entities), the point ID and the elevation can be exported to the output. The last block is available if a DTM is loaded.

## Horizontal network adjustment

Let's calculate the coordinates of points 5001, 5002, 5003 and 5004 using all available observations from points. GeoEasy uses GNU Gama for the network adjustment.

Before adjustment calculation the a priori standard deviations should be set in the **Calculation parameters** dialog. 3 arc seconds for directions and 3 mm + 3 ppm for distances.

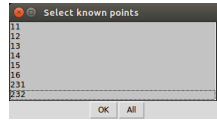
From the **Calculate** menu select **Horizontal network adjustment**. From the first point list select the unknown points (which coordinates are changed during adjustment). This list contains all point having preliminary or final coordinates.



*Unknown points*

## GeoEasy Step by Step

From the second point list select the fixed points (if no fixed points selected then free network will be calculated). This list contains point with final coordinates.



*Fixed points*

The result of the adjustment is shown in the Calculation results window. During the adjustment statistical tests are calculated to detect blunders but blunders are not eliminated automatically.

## Leveling network adjustment

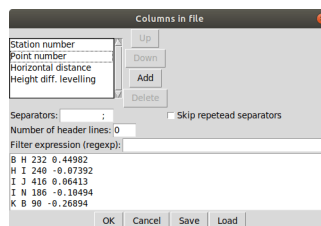
Leveling data can be loaded from GSI field-books created by digital leveling instruments (for example Leica DNA03 or NA3000 instruments). Manual input of height differences is also possible.

Let's start with an ASCII file (field-book) which contains start and endpoint, distance, height difference.

```
B H 232 0.44982
H I 240 -0.07392
I J 416 0.06413
I N 186 -0.10494
K B 90 -0.26894
K N 215 0.00234
J K 806 -0.17131
N H 408 0.17836
N J 634 0.1686
```

Field-book (leveling.dmp)

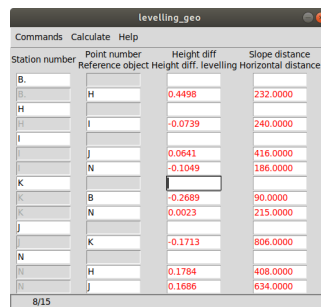
Let's load this field-book into GeoEasy. Select **File/Load** from the menu of the main window. Select *Fieldbook (\*.dmp, \*.DMP)* type. The leveling.dmp file is in the demodata sub-directory of GeoEasy installation folder. Select the file and click on Open button. A dialog will be displayed where fields of the input file can be set. Remove the unnecessary fields (*Horizontal angle, Vertical angle, lope distance, signal height, instrument height*) and add *horizontal distance* and *Height diff. leveling*. Don't forget to add *space* to the separators.



*Loading leveling.dmp*

Open the field-book (**Edit/Observations**) and change the mask ( **Commands/Mask...**) to *leveling*. You can see nine observations.

## GeoEasy Step by Step

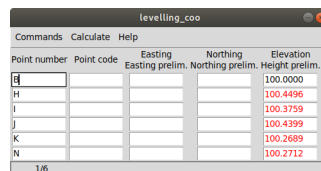


Station number	Point number	Height diff	Slope distance
Reference object	Height diff. levelling	Horizontal distance	
B	H	0.4498	232.0000
H	I	-0.0739	240.0000
I	J	0.0641	416.0000
J	N	-0.1049	186.0000
K	B	-0.2689	90.0000
K	N	0.0023	215.0000
J	K	-0.1713	806.0000
N	H	0.1784	408.0000
N	J	0.1686	634.0000

*Observations in leveling mask*

These observations were made by digital leveling instrument with a standard deviation of 0.3 mm/km. Change calculation parameters (**File/Calculation parameters...**), *Decimals in results* should be changed to 4. Check also *Standard deviation for leveling [mm/km]*, it should be 0.3.

We shall adjust this small leveling network. There are no elevations in the field-book, so first set the elevation of point *B* to 100.000. After it let's calculate preliminary elevations (**Calculations/Preliminary coordinates**)



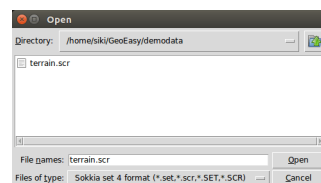
Point number	Point code	Easting	Northing	Elevation
		Easting prelim.	Northing prelim.	Height prelim.
B				100.0000
H				100.4496
I				100.3759
J				100.4399
K				100.2689
N				100.2712

*Preliminary elevations*

Now we can start leveling network adjustment (**Calculate/Leveling network adjustment**). Select all point as unknown. In the calculation result window a long result list is displayed and the coordinates in the coordinate list are updated.

## Digital terrain model

GeoEasy is capable to create TIN based Digital Terrain Models from the points in the loaded data sets or from a DXF file. *Triangle* open source project is used to generate triangles. There is a small electric field book in the demo data set called *terrain.scr*. Load the *scr* file using the **File/Load...** menu of the main window.



*Loading field book*

There are 77 points in the coordinate list, let's open a graphic window to see the points and turn off the the yellow observation lines and point name labels using the **Commands/Observations F4** and **Commands/Point names** from the menu of the graphic window.

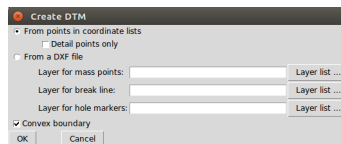
### Note

In the calculation results window you can see a table with collimation and index errors. If the observations were made in two faces, the average of face left and face right will be stored in the field-book.

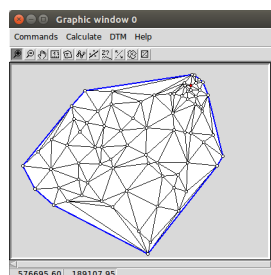
### Note

The colors used in the graphics window can be changed using **File/Colors...** from the menu of the main window.

Let's start to create a TIN, select **DTM/Create...** from the menu of the graphic window and press OK button in the *Create DTM* dialog and select directory and name for the DTM in the *Save as* dialog.

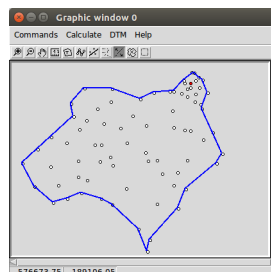


*DTM creation*



*TIN in the graphic window*

The convex hole of the points is filled by triangles which have minimal sum of perimeters. At the side of the model there are narrow triangles. These can be avoided by defining a non-convex boundary for the model. Unload the TIN by **DTM/Close** from the menu of graphic window. Using the Break line tool from the toolbar draw the boundary of the model.

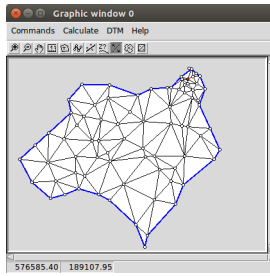


*Non-convex boundary for TIN*

Select again the **DTM/Create...** from the menu and unselect convex boundary checkbox. Triangles are created inside the closed polyline.



# GeoEasy Step by Step

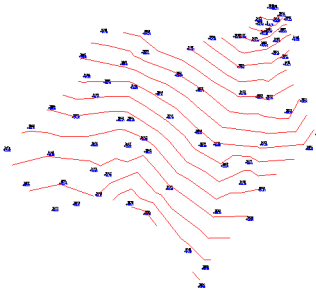


### Non-convex boundary for TIN

### Note

Break lines can be added, those can be open polylines. If convex boundary is unchecked at least one closed polyline must be added to the model.

Let's add contours to our model, **DTM/Contours** from the menu. Input 1 (meter) for contour interval. Finally export contours to an AutoCAD DXF file using **Commands/DXF output**.



## Contours in LibreCAD

### Note

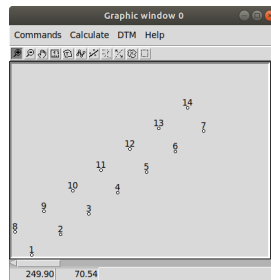
TINs are stored in three ASCII files (.pnt for points, .dtm for triangles and .pol for break lines).

## Regression calculation

Regression calculation can be used to find best fitting geometrical shape to the coordinates of points. Least square adjustment is used to find the parameters of the best fitting geometry. The *reg.geo* data set in the demodata folder will be used in this chapter. Load the data set to try regression algorithms.

## Regression line

## GeoEasy Step by Step



*Crane track points*

Observations were made along a crane track. Points from 1 to 7 are on the right rail and points from 8 to 14 on the left rail. Let's first fit a 2D line on the right side rail, **Calculate/Regression calculation/2D Line** from the menu.

2019.03.30 13:59 - 2D Line  
 $N = +0.71863307 * E - 100.619$   
 Angle from east: 35-42-08  
 Correlation coefficient: 1.000

Point num	E	N	dE	dN	dist
1	223.563	60.040	-0.001	0.001	0.001
2	231.684	65.879	0.001	-0.001	0.001
3	239.801	71.714	0.002	-0.002	0.003
4	247.926	77.543	-0.003	0.004	0.005
5	256.046	83.388	0.002	-0.002	0.003
6	264.161	89.211	-0.002	0.003	0.004
7	272.285	95.058	0.002	-0.002	0.003

RMS=0.003

The results are printed in the *Calculation results* window. Beside the equation of the line the direction and correlation are also calculated. From the table of the point-line distances (*dist*) can be read.

This case we had better to fit two parallel lines using **Calculate/Regression calculation/Parallel 2D lines**. From the first point list select the points on right side rail (1-7) and press OK. From the second point list select points on left side rails (8-14).

2019.03.30 14:05 - Parallel 2D lines  
 $N = +0.71870599 * E - 100.637$   
 $N = +0.71870599 * E - 90.785$   
 Angle from east: 35-42-18  
 Horizontal distance: 8.000  
 Correlation coefficient: 1.000

Point num	E	N	dE	dN	dist
1	223.563	60.040	0.000	-0.000	0.001
2	231.684	65.879	0.001	-0.002	0.002
3	239.801	71.714	0.002	-0.003	0.003
4	247.926	77.543	-0.003	0.004	0.005
5	256.046	83.388	0.001	-0.002	0.002
6	264.161	89.211	-0.003	0.004	0.005
7	272.285	95.058	0.001	-0.001	0.001
8	218.896	66.533	-0.002	0.003	0.003
9	227.017	72.376	0.001	-0.002	0.002

## GeoEasy Step by Step

10	235.137	78.206	-0.002	0.002	0.003
11	243.254	84.045	0.001	-0.001	0.001
12	251.374	89.883	0.002	-0.002	0.003
13	259.496	95.715	-0.001	0.001	0.001
14	267.611	101.550	0.001	-0.001	0.001
RMS=0.004					

## Regression plane

On a diaphragm wall points were scanned by a robotic total station, points from *Scan0676* to *Scan0915*. Let's check if the wall is vertical using **Calculate/Regression calculation/Vertical plane**. In the point list select all *Scan* points and press OK.

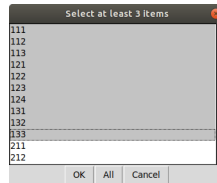
2019.03.30 15:25 - Vertical plane					
N = -0.00119324 * E +0.054					
Angle from east: - 0-04-06					
Correlation coefficient: -0.390					
Point num	E	N	dE	dN	dist
Scan0676	68.799	-0.004	-0.000	-0.024	0.024
Scan0677	67.798	-0.004	-0.000	-0.022	0.022
Scan0678	66.789	0.002	-0.000	-0.028	0.028
Scan0679	65.790	0.001	-0.000	-0.026	0.026
Scan0680	64.789	0.001	-0.000	-0.024	0.024
Scan0681	63.788	0.003	-0.000	-0.025	0.025
Scan0682	62.786	0.003	-0.000	-0.024	0.024
...					
RMS=0.024					

We got two points for the planned position of the diaphragm wall, these are points S2 and S3. Let's check the distances from the planned position. Select **Calculate/Regression calculation/Distance from line** from the menu (vertical plane is the same as 2D line in this situation). First select the two points from the plan S2 and S3 from the point list. From the second point list select *Scan* points. In the *Calculation results* list we get the distances of the scanned points from the planned positions.

2019.03.30 15:45 - Distance from the S2 - S3 line					
Point num	E	N	Distance	dE	dN
Scan0676	68.799	-0.004	-0.004	0.000	0.004
Scan0677	67.798	-0.004	-0.004	0.000	0.004
Scan0678	66.789	0.002	0.002	0.000	-0.002
Scan0679	65.790	0.001	0.001	0.000	-0.001
Scan0680	64.789	0.001	0.001	0.000	-0.001
Scan0681	63.788	0.003	0.003	0.000	-0.003
Scan0682	62.786	0.003	0.003	0.000	-0.003
Scan0683	61.785	0.003	0.003	0.000	-0.003
Scan0684	60.784	0.002	0.002	0.000	-0.002
Scan0685	59.784	0.003	0.003	0.000	-0.003
...					

## Regression circle

There are points on five horizontal sections of a chimney. Let's fit a regression circle on lowest section, point ids like '1nn'. Select **Calculate/Regression calculation/Circle** from the menu of any window. A list of point ids is displayed in a new window. Select all points from 111 to 133 and press OK button. You will be asked for the radius of the circle. Let the *unknown* value in the input box to calculate radius from the data. You can give a radius if it is known and you don't want to get an estimated value from the circle regression.



*Points for circle regression*

The result of the calculation is displayed in the *Calculation results* window. *E0* and *N0* are the coordinates of the center of the circle, *R* is the radius. The tabular data show the coordinates of the used points and the differences from the best fitting circle (in east, north and radial direction).

2019.03.29 23:10 - Circle

E0 = 635.693 N0 = 271.517 R = 2.442

Point num	E	N	dE	dN	dR
111	633.661	270.152	0.005	0.003	-0.005
112	635.355	269.096	0.000	0.002	-0.002
113	637.586	269.966	-0.004	0.003	-0.005
121	633.975	269.779	0.001	0.001	-0.001
122	634.477	269.404	-0.002	-0.004	0.005
123	634.520	269.378	-0.001	-0.003	0.003
124	634.520	269.378	-0.001	-0.003	0.003
131	637.898	270.468	0.000	-0.000	0.000
132	638.132	271.428	0.001	-0.000	0.001
133	638.129	271.655	0.002	0.000	0.002

RMS=0.003