# *NGS Toolkit, Part 4:* General Geodetic Computations

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Some utilities you use everyday and some you don't. You probably don't need to compute a geodetic inverse very often, or convert from geocentric coordinates X, Y, and Z to latitude, longitude, and ellipsoid heights on a daily basis, so you probably don't have these utilities on your home computer. But, when you need them, where are they? Not to worry. They can be found in the NGS Geodetic Tool Kit!

The NGS Geodetic Tool Kit includes several general geodetic computational utilities including the geodetic inverse and forward utilities and the XYZ to latitude, longitude, height conversion utility. Here's a brief description of how they work.

The XYZ Coordinate Conversion utility allows for geodetic quality three dimensional positioning on an earth-centered ellipsoid. This utility provides a method for converting between geodetic latitude, longitude, and ellipsoid height (N,(,h) on the GRS80 ellipsoid to X, Y, and Z in the Conventional Terrestrial Reference System. The utility will also convert X, Y, and Z to N,(,h. The sketch below shows the relationship between the two coordinate systems. The XYZ Coordinate Conversion utility can be found online at: *www.ngs.noaa.gov/TOOLS/XYZ/xyz.html*

The geodetic inverse utility, INVERSE, is the tool for computing the geodetic azimuth and ellipsoid distance between two points on the ellipsoid, given their latitudes and longitudes. (The ellipsoid distance is the length of the shortest path on the surface of the ellipsoid which connects the two points.) The geodetic forward, utility FORWARD, is the tool for computing the latitude and longitude of a point, given the latitude and longitude of a starting point and the geodetic azimuth and ellipsoid distance between the points.

Formulae for INVERSE and FORWARD are taken from "Direct and Inverse Solutions of

Geodesics on the Ellipsoid with Application of Nested Equations" by T. Vincenty, published in *Survey Review*, April 1975, and available online at: www.ngs.noaa.gov/PUBS_LIB/pub_index.html.

The three-dimensional versions of the inverse and forward, utilities INVERS3D and FORWRD3D, compute a chord distance and include the height component. The user may input either geodetic positions in latitude, longitude, and ellipsoid height or rectangular coordinates, *i.e.*, X, Y, Z in the Conventional Terrestrial Reference System. The utilities will automatically convert between the two systems and return both coordinate sets for both stations. The utilities will also return the geodetic azimuth, the ellipsoidal distance, mark-to-mark distance (*i.e.*, the straight-line distance), delta height (difference in ellipsoid height), DX, DY, DZ (differential X, Y, and Z), and DN, DE, DU (differential north, east, and up using the FROM station as the origin of the NEU coordinate system). The FORWRD3D utility allows the user to input any one of the following four sets of parameters:

a) azimuth, ellipsoidal distance, delta height
b) azimuth, mark-to-mark distance, delta height
c) DX, DY, DZ
d) DN, DE, DU

In all four utilities, the azimuth being computed is the geodetic azimuth, which is not to be confused with an astronomic azimuth or a plane azimuth.

Here's a sample output:

The utilities INVERSE, INVERS3D, FORWARD, and FORWRD3D can be found online at: www.ngs.noaa.gov/TOOLS/Inv_Fwd/Inv_Fwd.html.

The XYZ Coordinate Conversion, INVERSE, INVERS3D, FORWARD, and FORWRD3D, are available in the NGS Geodetic Tool Kit along with a number of other utilities. Additional information about the entire suite of NGS Geodetic Tool Kit applications can be found online at: www.ngs.noaa.gov/TOOLS/.

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