HP-33S Calculator Program XYZ 1

Convert Latitude, Longitude and Height on any ellipsoid to XYZ Geocentric Co-ordinates

Programmer: Dr. Bill Hazelton

Date: March, 2005.

Line	Instruction	Display	User Instructions
X0001	LBL X		Press XEQ X
X0002	6378137		Value of a for WGS84/NAD83/GRS80
X0003	STO A		
X0004	0.006694381		Value of e^2 for WGS84/NAD83/GRS80
X0005	STO E		
X0006	INPUT A	6378137	Enter value of a if different
X0007	INPUT E	0.006694381	Enter value of e^2 if different
X0008	INPUT F		Enter ϕ of point
X0009	INPUT L		Enter λ of point
X0010	INPUT H		Enter h of point
X0011	RCL A		
X0012	1		
X0013	RCL F		
X0014	→HR		
X0015	SIN		
X0016	x^2		
X0017	RCLx E		
X0018	–		
X0019	√x		
X0020	÷		
X0021	STO V		
X0022	RCL+ H		
X0023	RCL F		
X0024	→HR		
X0025	COS		
X0026	×		
X0027	RCL L		
X0028	→HR		
X0029	COS		
X0030	×		
X0031	STO X		
X0032	VIEW X	X co-ordinate	X co-ordinate is displayed
X0033	RCL L		
X0034	→HR		
X0035	TAN		
X0036	×		
X0037	STO Y		
X0038	VIEW Y	Y co-ordinate	Y co-ordinate is displayed

Lat/Long/Ht to XYZ Geocentric Co-ordinates

Line	Instruction	Display	User Instructions
X0039	RCL V		
X0040	1		
X0041	RCL– E		
X0042	×		
X0043	RCL+ H		
X0044	RCL F		
X0045	→HR		
X0046	SIN		
X0047	×		
X0048	STO Z		
X0049	VIEW Z		Z co-ordinate is displayed
X0050	RTN		

Notes

(1) A program to convert latitude, longitude and ellipsoidal height on any ellipsoid to X, Y, Z geocentric co-ordinates.

(2) The assumption is that the distances are in meters, but by using feet for the semi-major axis of the ellipsoid, co-ordinates in feet will be produced.

(3) The program pre-enters the parameters for the WGS84/NAD83/GRS80 ellipsoid by default (in meters), to save you having to remember these. If you want a different ellipsoid, enter the appropriate a and e^2 values at the prompts (A and E).

(4) The resulting co-ordinates are displayed with a prompt or label. Note that the program does not clear registers after use. You can get ν for the point by using the RCL V keystrokes, for example.

(5) The latitude and longitude are entered in HP notation, i.e., DDD.MMSS. The height is assumed to be in the same units as the semi-major axis, by default, meters.

(6) It is critical to follow the sign convention with latitudes, longitudes and heights. Latitudes in the southern hemisphere are negative. Longitudes west of Greenwich are negative, i.e., all longitudes in the US are negative. Heights below the ellipsoid must be entered as negative.

Theory

The program implements the following four equations:

$$X = (\nu + h) \cos\phi \cos\lambda \quad [1]$$

$$Y = (\nu + h) \cos\phi \sin\lambda \quad [2]$$

$$Z = [\nu (1 - e^2) + h] \sin\phi \quad [3]$$

$$\nu = \frac{a}{\sqrt{1 - e^2 \sin^2 \phi}} \quad [4]$$

Lat/Long/Ht to XYZ Geocentric Co-ordinates

These provide a direct solution. Values for the ellipsoid (a and e^2) are requested, although default values for NAD83/WGS84/GRS80 are supplied (these can be overwritten). The latitude, longitude and ellipsoidal height of the point are requested of the user. The program supplies the solution in three stages.

Sample Computation

Inputs

a = 6 378 137 m
e^2 = 0.006 694 381 (WGS84/NAD83/GRS80 parameters)
ϕ = 35° 00' 00" N (entered as 35.0000) Latitude of point
λ = 75° 00' 00" W (entered as –75.0000) Longitude of point
h = 200 m Ellipsoidal height of point

Results

X = 1 353 776.483 m
Y = –5 052 362.616 m
Z = 3 637 981.622 m

Running the Program

Begin by pressing XEQ X

The calculator displays: A?
6,378,137.0000

This is the NAD83/WGS84/GRS80 ellipsoid semi-major axis. If this is OK, press R/S; if not key in correct value and press R/S.

The calculator displays: E?
0.006694381 (suitably rounded, according to your settings)

This is the eccentricity of the NAD83/WGS84/GRS80 ellipsoid, e^2. If this OK, press R/S; if not, key in correct value and press R/S.

The calculator displays: F?
[*Whatever value happens to be in this register*]

Key in the latitude of the point and press R/S. Use negative values for the southern hemisphere. In the given example, key in 35 and press R/S.

The calculator displays: L?
[*Whatever value happens to be in this register*]

Key in the longitude of the point and press R/S. Use negative values in the western hemisphere. In the given example, key in –75 and press R/S.

The calculator displays: H?
[*Whatever value happens to be in this register*]

Key in the ellipsoidal height for the point and press R/S. Use negative values for heights below the ellipsoid. In the given example, key in 200 and press R/S.

The calculator displays: X=
1,353,776.483 Press R/S

The calculator displays Y=
–5,052,362.616 Press R/S

Lat/Long/Ht to XYZ Geocentric Co-ordinates

The calculator displays: Z=
3,637,981.622

These calculations agree with the NGS website computations to within 0.003 m.

Storage Registers Used

A Semi-major axis of the ellipsoid, a. By default, set to 6378137 m

E Eccentricity of the ellipsoid, e^2. By default, set to 0.006694381.

F Latitude (geodetic) of the point, ϕ.

H Ellipsoidal height of the point, h.

L Longitude of the point, λ.

V The radius of curvature of the ellipsoid in the prime vertical, ν.

X Geocentric X co-ordinate of the point.

Y Geocentric Y co-ordinate of the point.

Z Geocentric Z co-ordinate of the point.

Note that this program overwrites the Z register, removing the value of 360 that some other programs use for correcting negative angles. Check this if using one of the closure programs.

Labels Used

Label **X** Length = 198 Checksum = B137

Use the length (LN=) and Checksum (CK=) values to check if program was entered correctly. Use the sample computation to check proper operation after entry.

Reference

The NGS website for the interactive XYZ ⇔ lat/long/height converter:

http://www.ngs.noaa.gov/TOOLS/XYZ/xyz.shtml