Bennett
2026 / Q1 / 7

Geomatics Hackathon

Our journey through the ups and downs of GeoHacks 2026

Activate the encryption key: Save the world.

Our task was simple.

Starting from a point of reference on campus, we were to follow the clues to translate, transpose, and track six final points. From there, we would analyze the spatial activation key ensure protection of the Intelligent Positioning System.

Project roadmap

Step 1

Locate the coordinates of the reference point using Novatel PowerPak 7 receiver.

Step 2

Interpret the clues to translate and transpose vectors

Step 3

Find points and develop a map of all coordinates

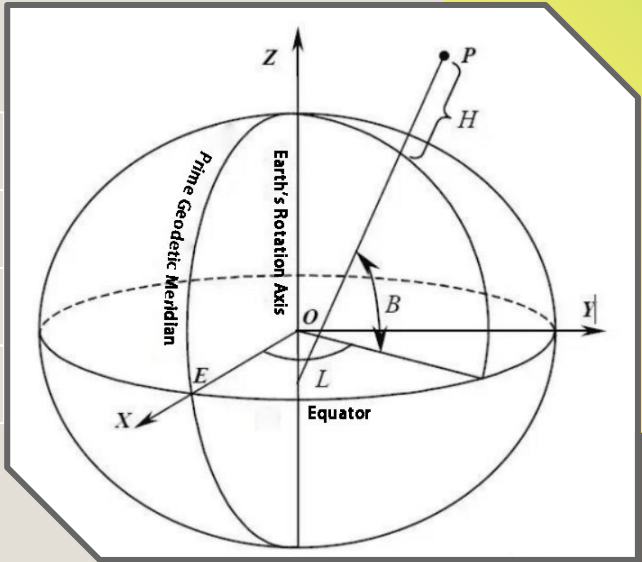
Step 4

Analyze the final vectors to find the solution!

Goal

Locate THE key and save the Intelligent Positioning System

How do we look at the world around us?



Geodetically:

- Earth is not a perfect sphere
- Complications when measuring height
- Done by measuring angle from center to surface of Earth

Global Cartesian:

- The X,Y,Z plane, with the origin at the Earth's center of mass and Z being the axis of rotation

Geodetic, Global Cartesian, Local Frame

Geodetic
(Global, Lat, Lon, H)

Local Cartesian
(E, N, U)

Mathematical formula using WGS84 ellipsoid

$$X = \left(\frac{a}{\sqrt{1 - e^2 \sin^2 \phi}} + h\right) \cos\phi \cos\lambda$$

$$Y = \left(\frac{a}{\sqrt{1 - e^2 \sin^2 \phi}} + h\right) \cos\phi \sin\lambda$$

$$Z = \left(\frac{a(1 - e^2)}{\sqrt{1 - e^2 \sin^2 \phi}} + h\right) \sin\phi$$

Rotation matrix multiplication

$$R_{To}^{From}$$

$$R_{NEU}^{XYZ} = \begin{bmatrix} -\sin\varphi\cos\lambda & -\sin\varphi\sin\lambda & \cos\varphi \\ -\sin\lambda & \cos\lambda & 0 \\ \cos\varphi\cos\lambda & \cos\varphi\sin\lambda & \sin\varphi \end{bmatrix}$$

$$R_{XYZ}^{NEU} = {R_{NEU}^{XYZ}}^{T}$$

Global Cartesian
(X, Y, Z)

Building Blocks for Every Solution

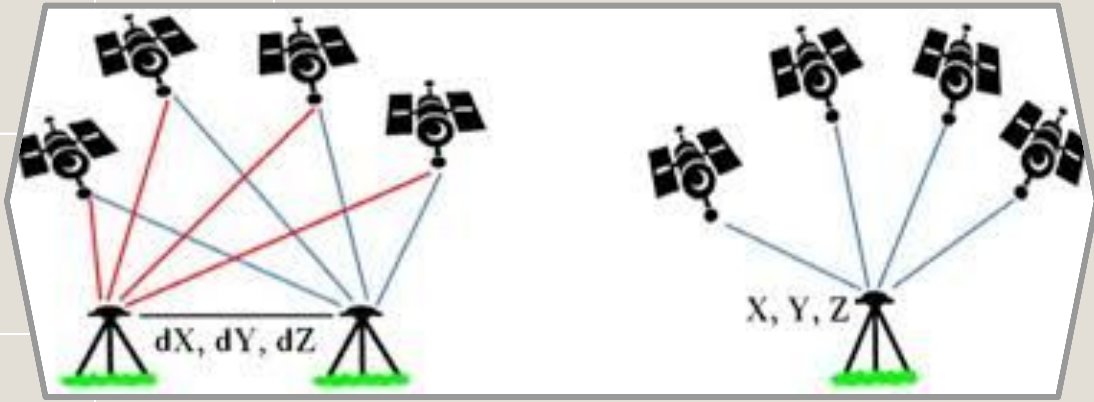
- Developed individual functions to convert coordinates
- Allowed for use of common functions to be modular
- Link to github is here: Team Bennett Github

Programmatically parse a log entry to extract data	Convert a local bearing to ENU	Convert between a Global Cartesian point and a Geodetic point	Convert between a Global Cartesian point and an ENU point

RTK V.S. PPP

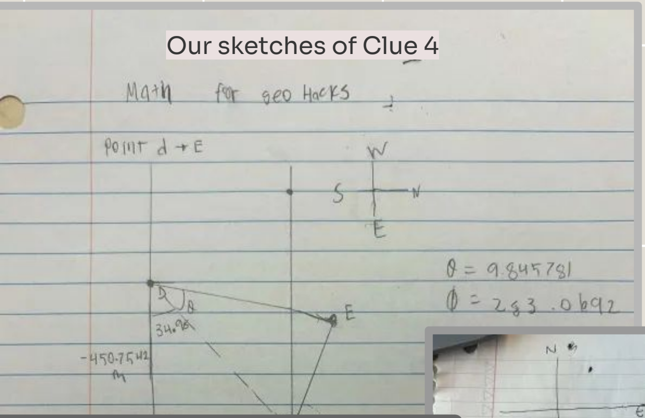
- Valued fast connection speed of RTK & designed our workflow for RTK
- Used NAD83
- Got both PPP and RTK data from ENGG rover station
- Difference between the two measurements averaged to be 0.002 meters (2 mm)

RTK (Left) v.s. PPP (Right)



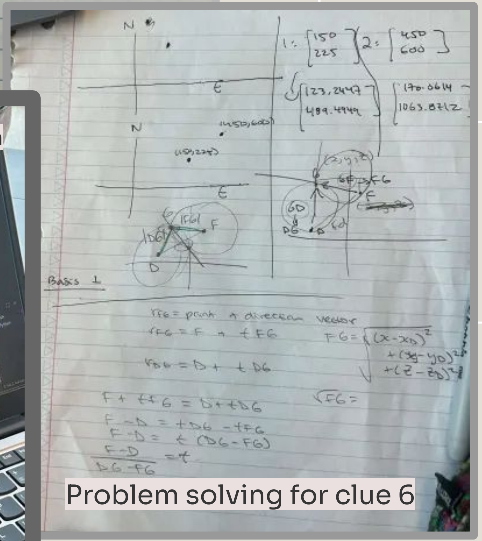
NovAtel Antenna offsets for our measurements in antenna calibration

Logic & Problem Solving



Our sketches of Clue 4

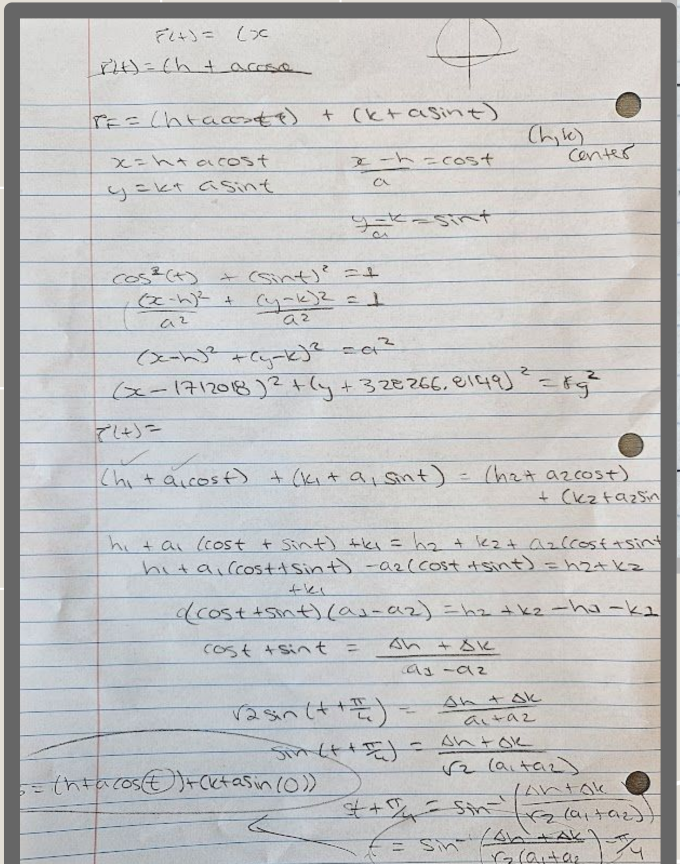

Translating written solution to Python



Problem solving for clue 6

- Started by reading through clues and finding important data
- Figured out what needed to be done to the measurements to find the next point
- Did most of problem setup on paper, then translated it to code
- Tested code, then used it to generate our coordinates in the geodetic frame
- Plotted our coordinates in Google Earth

Math for Clue 6



$\vec r(t) = (x$

$\vec r(t) = (h + a\cos\theta$

$r_F = (h + a\cos t) + (k + a\sin t)$ (h,k) center

$x = h + a\cos t$ $\frac{x-h}{a} = \cos t$

$y = k + a\sin t$ $\frac{y-k}{a} = \sin t$

$\cos^2(t) + (\sin t)^2 = 1$

$\frac{(x-h)^2}{a^2} + \frac{(y-k)^2}{a^2} = 1$

$(x-h)^2 + (y-k)^2 = a^2$

$(x - 1712018)^2 + (y + 328266.8149)^2 = r_G^2$

$\vec r(t) =$

$(h_1 + a_1\cos t) + (k_1 + a_1\sin t) = (h_2 + a_2\cos t) + (k_2 + a_2\sin$

$h_1 + a_1(\cos t + \sin t) + k_1 = h_2 + k_2 + a_2(\cos t + \sin t$

$h_1 + a_1(\cos t + \sin t) - a_2(\cos t + \sin t) = h_2 + k_2$ $+ k_1$

$(\cos t + \sin t)(a_1 - a_2) = h_2 + k_2 - h_1 - k_1$

$\cos t + \sin t = \frac{\Delta h + \Delta k}{a_1 - a_2}$

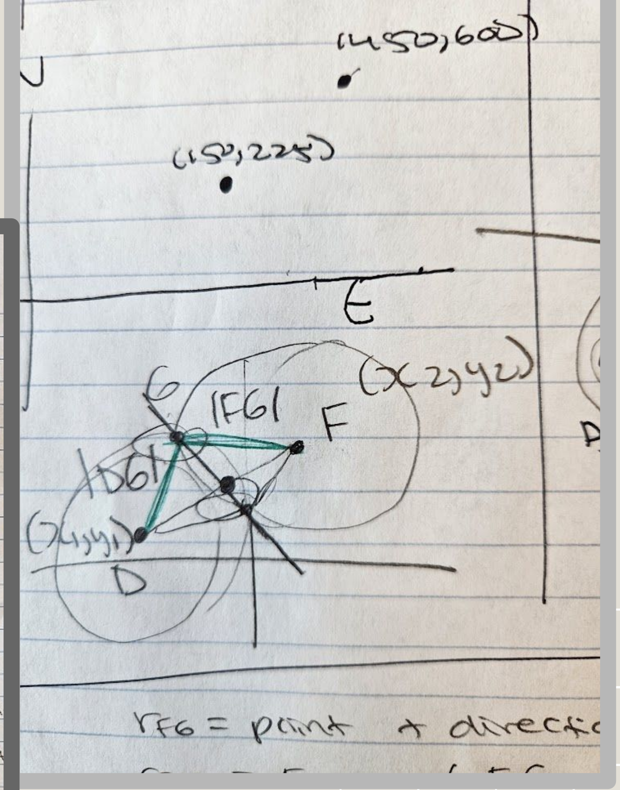
$\sqrt{2}\sin(t + \frac{\pi}{4}) = \frac{\Delta h + \Delta k}{a_1 + a_2}$

$\sin(t + \frac{\pi}{4}) = \frac{\Delta h + \Delta k}{\sqrt{2}(a_1 + a_2)}$

$= (h + a\cos(t)) + (k + a\sin(0))$

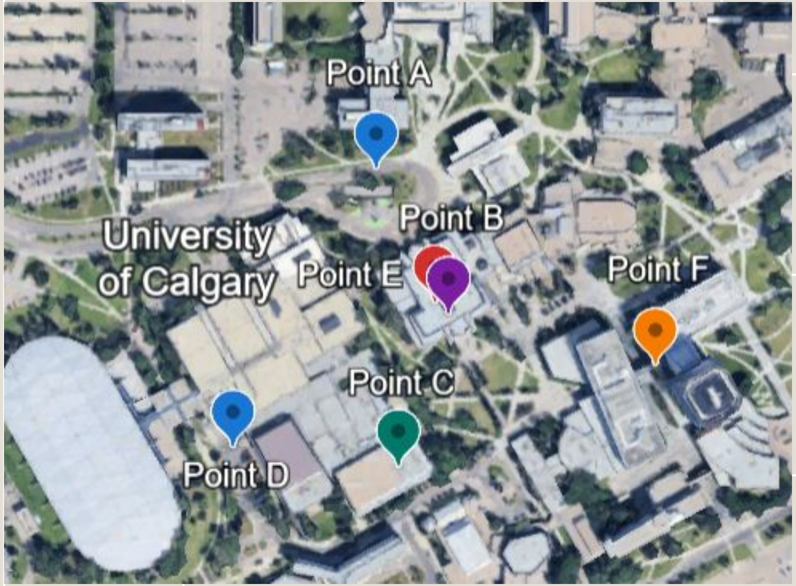
$t + \pi/4 = \sin^{-1}\left(\frac{\Delta h + \Delta k}{\sqrt{2}(a_1 + a_2)}\right)$

$= \sin^{-1}\left(\frac{\Delta h + \Delta k}{\sqrt{2}(a_1 + a_2)}\right) - \pi/4$



Visualization

Visualization of calculated points



Geodetic Point Coordinates

A is (51.07899643518, -114.13251416136, 1114.2977)

B is (51.077963288741124, -114.13169186367365, 1110.5887405816466)

C is (51.07687585204031, -114.13226076202659, 1110.0447396095842)

D is (51.07701380253775, -114.13413562901339, 1108.4798089712858)

E is (51.07845541586214, -114.13184531428247, 1115.4264941904694)

F is (51.077594601129166, -114.12934208399348, 1151.2811726192012)