## Short Answer

**1.** The shortest line on an ellipsoid surface is called a(n) _geodesic_ and is shaped like a(n) ___S___ .

**2.** The _deflection of the vertical_ is the angle between the ellipsoidal normal and gravity at a point.

**3.** How many UTM Zones cover Wisconsin? ___2___ SPC Zones? ___3___ .

## Problem (1)

Station *Long*, PID QN0259, is an NSRS First Order horizontal control point in Washburn County. When it was originally monumented in 1922 an Azimuth Mark was also set and the direction between them measured. Using the information on *Long*'s data sheet, along with any other resources, determine the Washburn County Coordinate System grid azimuth from *Long* to its Azimuth Mark.

From *Long*'s data sheet:

```
QN0259                          *CURRENT SURVEY CONTROL
QN0259   _____
QN0259* NAD 83(1996) POSITION- 45 58 27.41344(N) 091 35 38.32188(W)   ADJUSTED
QN0259* NAVD 88 ORTHO HEIGHT -   367.967 (meters)    1207.24  (feet) ADJUSTED
QN0259   _____

QN0259| PID    Reference Object                   Distance       Geod. Az  |
QN0259|                                                          dddmmss.s |
QN0259| CJ5260 LONG AZ MK                                        1414837.8 |
```

The geodetic azimuth to the Azimuth Mark is 141°48'37.8"

Using *ConCoord*[1]:

| Results... | |
|---|---|
| North | 622,793.7761 sft |
| East | 816,148.0087 sft |
| Convergence | +0°08'10.04" |
| Scale | 0.99999 46093 |

$t = \alpha - \gamma$

$= 141°14'37.8" - (+0°08'10.0") =$ **141°06'27.8"**

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[1] The *ConCoord* conversion software is available at https://jerrymahun.com/index.php/home/software/218-coordinate-conversion

## Problem (2)

Station *Bad*, PID NH1307, is a Third Order horizontal control point in Dane County. The horizontal distance from it to the Center Quarter corner of Sec 31 is measured as 3215.67 ft. The partial topoquad shows the line; the contour interval is 10 ft.
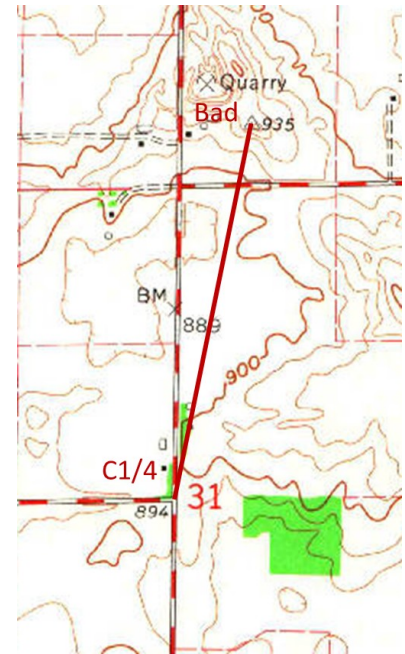
## Part (A)

Determine the line's grid length in the Wis South State Plane Coordinate System. Is it significantly different from the measured horizontal distance?

From *Bad*'s data sheet:

```
NH1307                          *CURRENT SURVEY CONTROL
NH1307    _____
NH1307* NAD 83(1991) POSITION- 42 51 43.07762(N) 089 14 18.17955(W)   ADJUSTED
NH1307* NAD 83(1991) ELLIP HT-   250.696 (meters)        (10/21/99)   ADJUSTED
NH1307* NAVD 88 ORTHO HEIGHT -   284.7   (meters)      934.   (feet) VERTCON3
NH1307    _____
NH1307  GEOID HEIGHT    -          -34.135 (meters)                  GEOID18
...
NH1307;                    North          East    Units Scale Factor Converg.
NH1307;SPC WI S    -     96,040.884   662,239.481   MT  0.99997655   +0 31 23.9
NH1307;SPC WI S    -    315,094.13  2,172,697.36   sFT  0.99997655   +0 31 23.9
NH1307;UTM  16     - 4,747,916.901   317,141.652    MT  1.00001137   -1 31 23.0
NH1307
NH1307!            -  Elev Factor  x  Scale Factor =   Combined Factor
NH1307!SPC WI S    -   0.99996069  x   0.99997655  =   0.99993724
NH1307!UTM  16     -   0.99996069  x   1.00001137  =   0.99997206
```

If we use the CF at *Bad:*

$$\text{Grid} = 3215.67 \text{ ft} \times 0.99993\ 724 = 3215.468 \text{ ft}$$

If we take into account the elevation both endpoints of the line:

From topoquad, elev at the C1/4 corner is 894 ft. Average line elevation is:

$$h = \frac{934 + 894}{2} = 914 \ ft$$

Convert the geoid hight to ft:

$$N = -34.135 \ m \ \times \frac{39.37 \ in}{1 \ m} \times \frac{1 \ ft}{12 \ in} = -111.99 \ ft$$

Compute grid distance

$$Grid = 3215.67 \ ft \times \left[ \frac{20,902,000 \ ft}{20,902,000 \ ft - 111.99 \ ft + 914 \ ft} \right] \times 0.99997 \ 655$$

$$= 3215.471 \ ft$$

This is a better grid distance since it takes into account both elevations. However, it's not much different (0.003 ft) than using *Bad*'s CF so either us OK.

The distortion between ground and grid is:

$$diff = 3215.67 \ ft - 3215.471 \ ft \ = \ 0.199 \ ft$$

$$distortion = \frac{0.199 \ ft}{3215.67 \ ft} = \frac{1}{16,160}$$

In light of today's measurement accuracies, 1/16,160 is a significant difference.
Answer: Grid dist = 3215.471 ft; distortion is significant

## Part (B)

Determine the line's grid length in the Dane County Coordinate System. Is it significantly different from the measured horizontal distance?

Use *Bad*'s Geodetic coordinates with *ConCoord* to determine the Dane County Coord System attributes of the point.

Use the same geoid and orthometric heights as in **Part (A).**

| Results... | |
|---|---|
| North | 405,348.1065 sft |
| East | 860,293.1675 sft |
| Convergence | +0°07'31.95" |
| Scale | 1.00004 50088 |

$$Grid = 3215.67 \ ft \times \left[ \frac{20,902,000 \ ft}{20,902,000 \ ft - 111.99 \ ft + 914 \ ft} \right] \times 1.00004 \ 50088$$

$$= 3215.691 \ ft$$

$$diff = 3215.67 \ ft - 3215.691 \ ft \ = \ -0.021 \ ft$$

$$distortion = \frac{0.021 \ ft}{3215.67 \ ft} = \frac{1}{153,130}$$

A distortion of 1/153,130 is insignificant unless performing a very high order control survey- this is the reason for a low distortion projection (LDP). Use ground as grid.
Answer:  Use ground as grid: 3215.67 ft; distortion is insignificant

## Problem (3)

NSRS Stations *Mollette Lake* (AB508) and *Deer Farm* (AB8436) are located in Burnett County. What is the Burnett County Coordinate System grid distance between them?

From *Mollette Farm's* datasheet

```
AB8508                          *CURRENT SURVEY CONTROL
AB8508     _____
AB8508* NAD 83(2011) POSITION- 45 54 29.83055(N) 092 12 34.08643(W)   ADJUSTED
AB8508* NAD 83(2011) ELLIP HT-   273.675 (meters)        (06/27/12)   ADJUSTED
AB8508* NAD 83(2011) EPOCH   -  2010.00
AB8508* NAVD 88 ORTHO HEIGHT -   300.6   (meters)      986.    (feet) GPS OBS
AB8508     _____
```

From *Deer Farm's* datasheet

```
AB8436                          *CURRENT SURVEY CONTROL
AB8436     _____
AB8436* NAD 83(2011) POSITION- 45 54 09.27626(N) 092 09 24.78270(W)   ADJUSTED
AB8436* NAD 83(2011) ELLIP HT-   282.230 (meters)        (06/27/12)   ADJUSTED
AB8436* NAD 83(2011) EPOCH   -  2010.00
AB8436* NAVD 88 ORTHO HEIGHT -   309.3   (meters)     1015.    (feet) GPS OBS
AB8436     _____
```

Use *ConCoord* to determine Burnett County coordinates of both points, then invert between the coordinates to determine the distance.

| Results... | | Results... | |
|---|---|---|---|
| North | 198,620.9352 sft | North | 196,584.8906 sft |
| East | 273,212.8753 sft | East | 286,607.2359 sft |
| Convergence | +0°10'41.93" | Convergence | +0°12'57.87" |
| Scale | 1.00003 83980 | Scale | 1.00003 83864 |

$$\Delta N = 198,620.935 - 196,584.891 = 2036.044 \ ft$$
$$\Delta E = 273,212.857 - 286,607.236 = -13,394.379 \ ft$$
$$L = \sqrt{(2036.044)^2 + (13,394.379)^2} = \underline{13,548.242 \ ft}$$