

## Direct Data Entry

- COGO – Coordinate geometry
- COGO involves directly entering the coordinates measured in the field,
- Coordinates may be tagged with attribute data in the field, e.g. well depth or pressure, when their locations are measured

## **Survey instrument for collection of coordinate geometry data**

Theodolite or Transit –  
measurement of horizontal and  
vertical angles

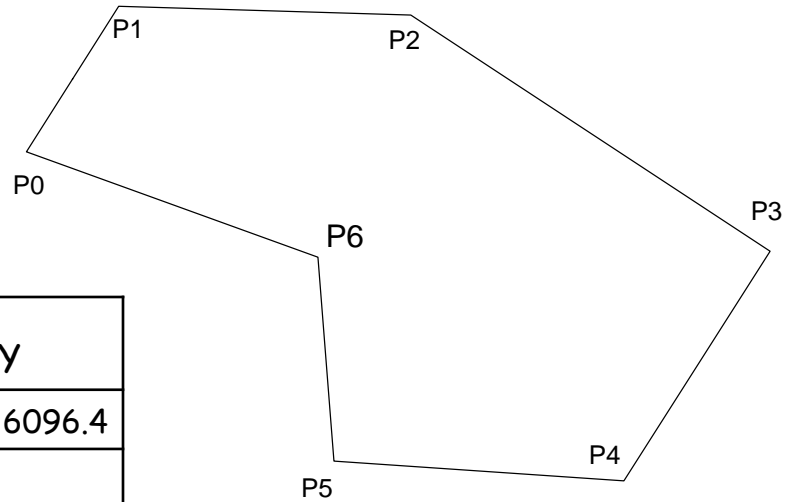
Level – measurement of vertical  
angles

Electronic Distance Meter -  
measurement of distance

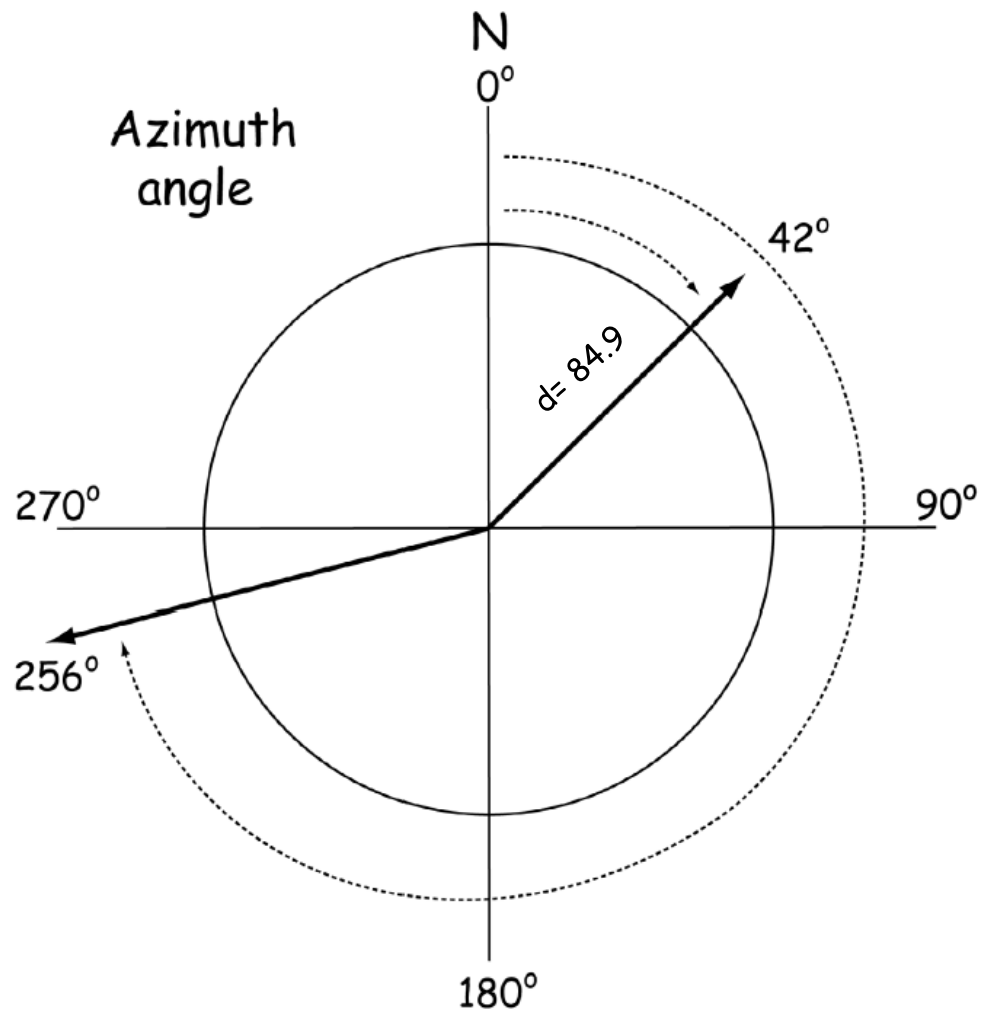
Total Station – measurement of  
angles and distances



Given a Table of Azimuths and Distances, What are the Coordinates?



	azimuth	distance	X	Y
p0			10128.3	6096.4
p1	32.4	122		
p2	91.7	207		
P3	123.3	305		
P4	212.5	193		
P5	273.9	206		
P6	355.5	145		





# Sine – Cosine – Tangent

Very Basic Trigonometry

Glenn  
Research  
Center

Terminology:



Definitions:

Assign a name to the **ratio** of the length of the sides of a right triangle

Sine:

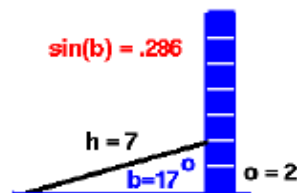
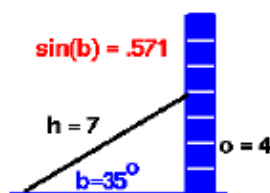
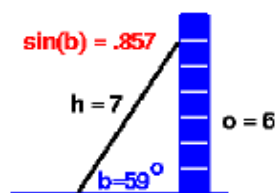
$$\sin(b) = \frac{o}{h}$$

Cosine:

$$\cos(b) = \frac{a}{h}$$

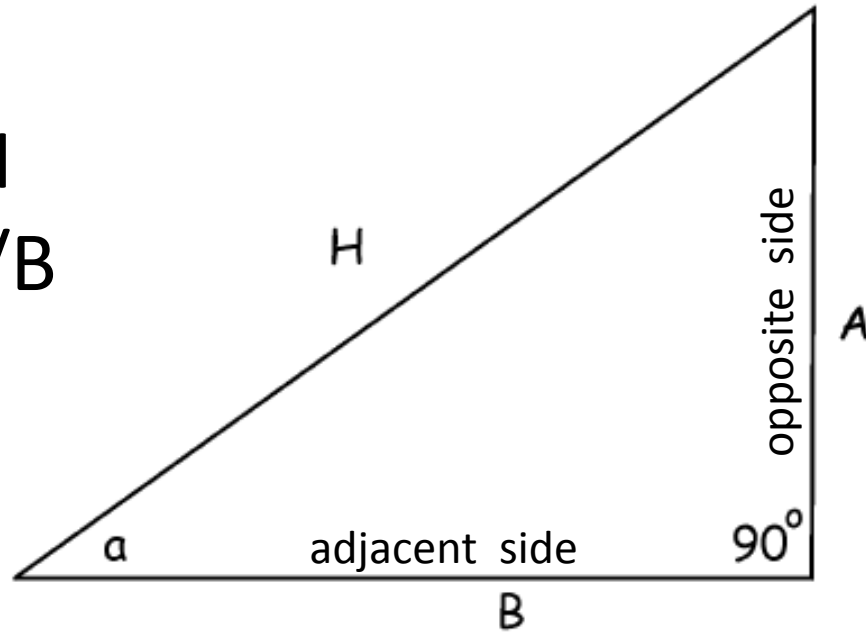
Tangent:

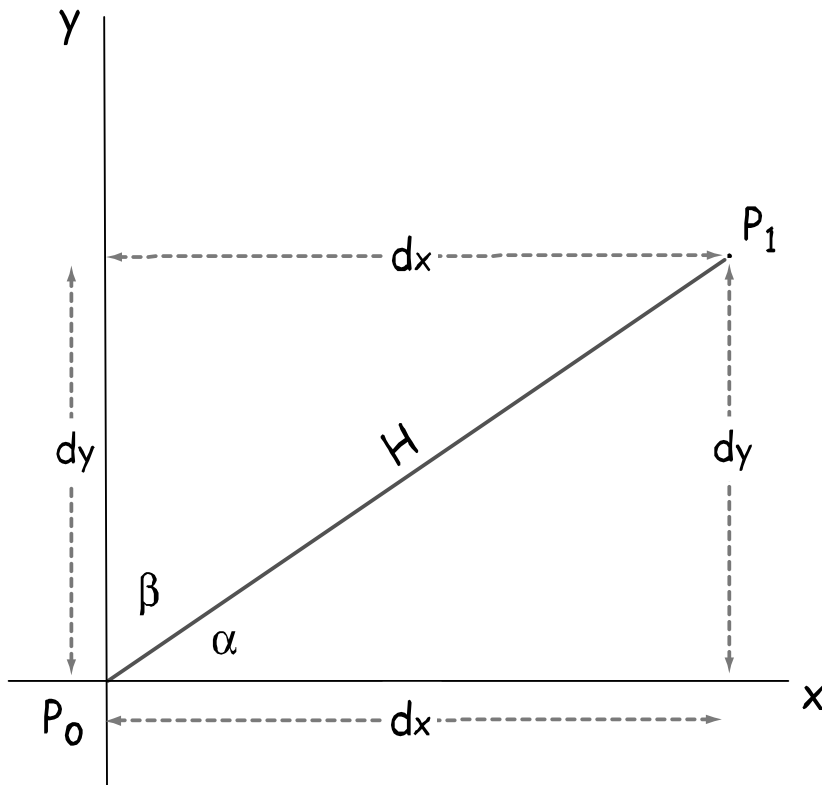
$$\tan(b) = \frac{o}{a}$$



The value of each ratio depends only on the size of the angle.

sine (a) = A/H  
cosine (a) B/H  
tangent (a) A/B





$$\alpha + \beta = 90^\circ$$

$$dy = H \cdot \sin(\alpha)$$

$$dy = H \cdot \cos(\beta)$$

$$dx = H \cdot \cos(\alpha)$$

$$dx = H \cdot \sin(\beta)$$

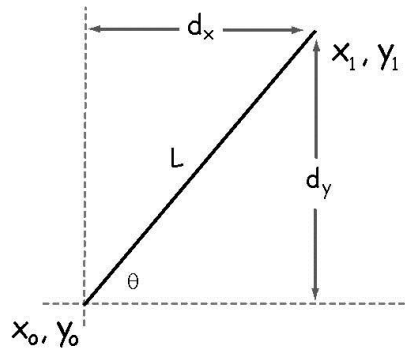
$$\text{if } \alpha + \beta = 90^\circ$$

then

$$\sin(\alpha) = \cos(\beta)$$

$$\sin(\beta) = \cos(\alpha)$$

## Coordinate geometry (COGO)



$$x_1 = x_0 + d_x$$

$$y_1 = y_0 + d_y$$

$$d_x = L \cdot \cos(\theta)$$

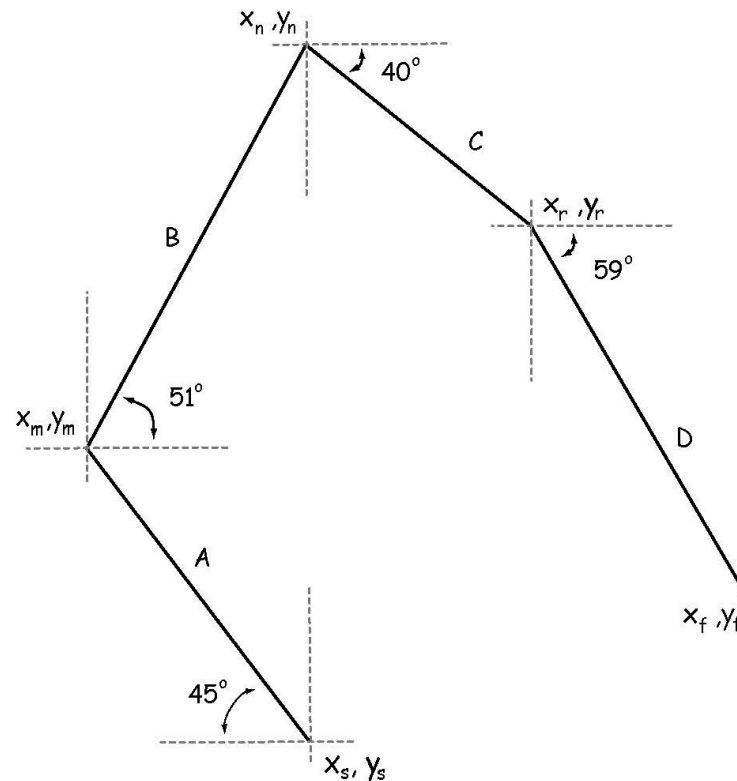
$$d_y = L \cdot \sin(\theta)$$

therefore

$$x_1 = x_0 + L \cdot \cos(\theta)$$

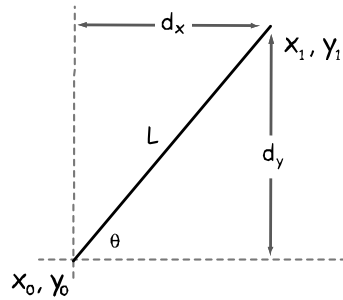
$$y_1 = y_0 + L \cdot \sin(\theta)$$

## Traverse





### Coordinate geometry (COGO)



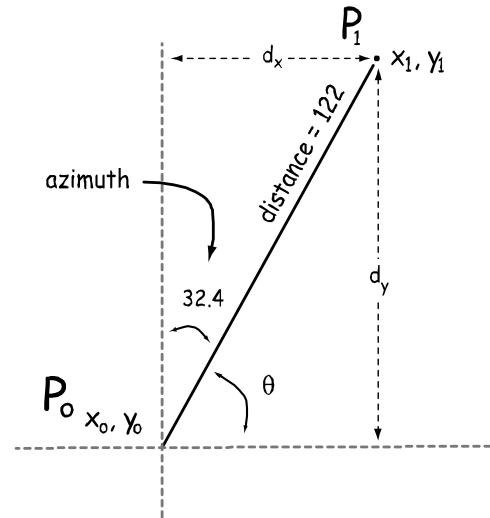
$$\begin{aligned}x_1 &= x_0 + dx \\y_1 &= y_0 + dy \\dx &= L \cdot \cos(\theta) \\dy &= L \cdot \sin(\theta)\end{aligned}$$

therefore

$$\begin{aligned}\mathbf{x_1} &= \mathbf{x_0 + L \cdot \cos(\theta)} \\y_1 &= y_0 + L \cdot \sin(\theta)\end{aligned}$$

Given  $x_0 = 10,128.3$  and  $y_0 = 6,096.4$ , the distance from  $P_0$  to  $P_1$  is measured at 122, and the azimuth angle from  $P_0$  to  $P_1$  is  $32.4^\circ$ ,

what are the coordinates  $x_1, y_1$  at point  $P_1$ ?



$$\theta = 90 - 32.4 = 57.6$$

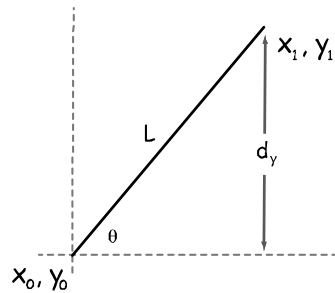
$$\begin{aligned}dx &= L \cdot \cos(\theta) = 122 \cdot \cos(57.6) \\&= 122 \cdot 0.535828 \\&= 65.4\end{aligned}$$

$$\begin{aligned}dy &= L \cdot \sin(\theta) = 122 \cdot \sin(57.6) \\&= 122 \cdot 0.844327 \\&= 103.0\end{aligned}$$

$$\begin{aligned}\mathbf{x_1} &= \mathbf{x_0 + dx} = \mathbf{10,128.3 + 65.4} \\&= \mathbf{10,193.7}\end{aligned}$$

$$\begin{aligned}\mathbf{y_1} &= \mathbf{y_0 + dy} = \mathbf{6,096.4 + 103.0} \\&= \mathbf{6,199.4}\end{aligned}$$

Coordinate geometry (COGO)



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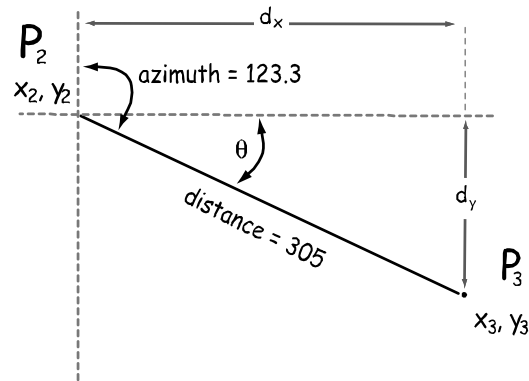
therefore

$$x_1 = x_0 + L \cdot \cos(\theta)$$

$$y_1 = y_0 + L \cdot \sin(\theta)$$

Given  $x_2 = 10,400.6$  and  $y_2 = 6,193.3$ , the distance from  $P_2$  to  $P_3$  is measured at 305, and the azimuth angle from  $P_2$  to  $P_3$  is  $123.3^\circ$ ,

what are the coordinates  $x_3, y_3$  at point  $P_3$ ?



$$\theta = 123.3 - 90 = 33.3$$

$$\begin{aligned} \text{then } L \cdot \cos(\theta) &= 305 \cdot \cos(33.3) \\ &= 305 \cdot 0.835808 \\ &= 254.9 \end{aligned}$$

note,  $dy$  is negative, so  $dy$  is

$$\begin{aligned} -L \cdot \sin(\theta) &= -305 \cdot \sin(33.3) \\ &= -305 \cdot 0.54902 \\ &= -167.5 \end{aligned}$$

$$\begin{aligned} x_3 = x_2 + dx &= 10,400.6 + 254.9 \\ &= 10,655.5 \end{aligned}$$

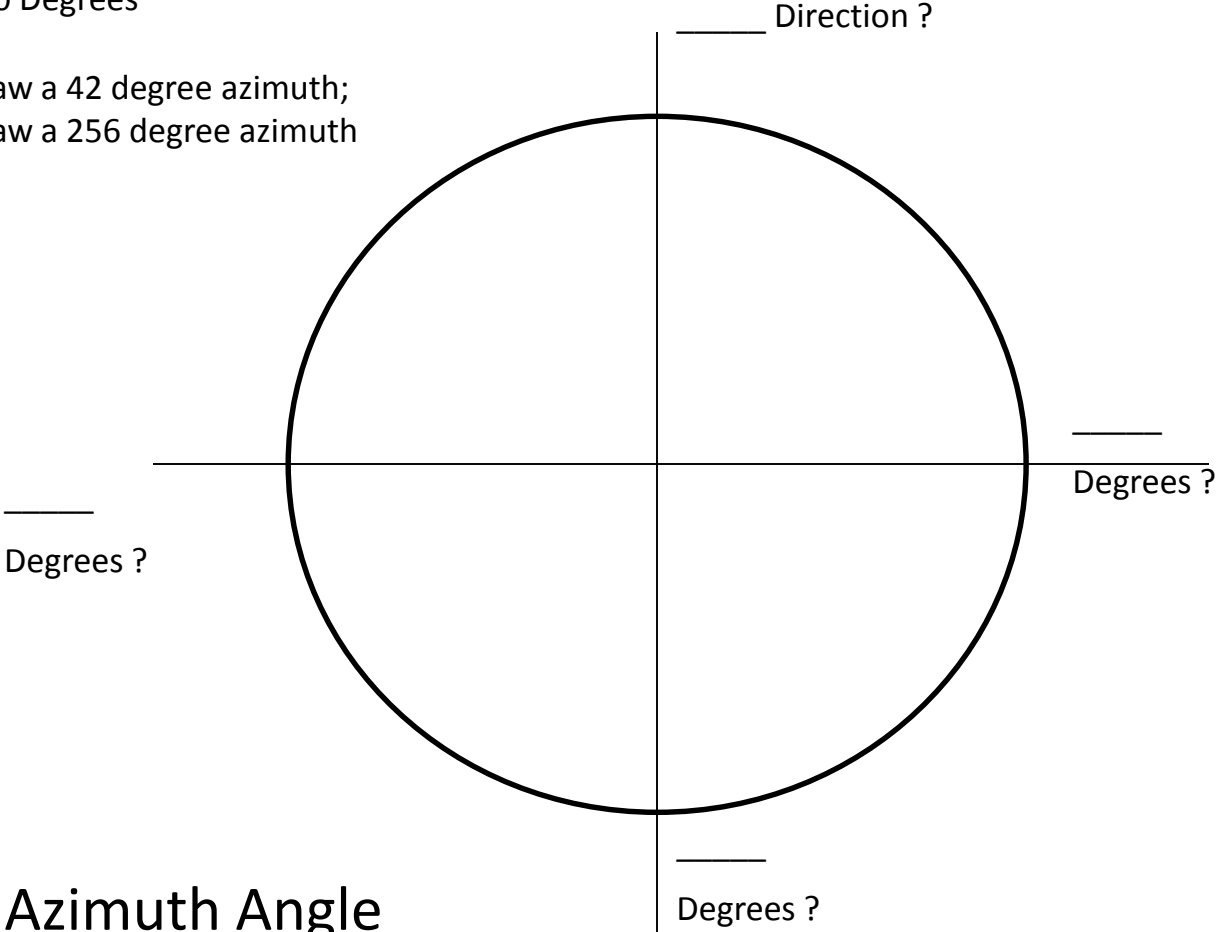
$$\begin{aligned} y_3 = y_2 + dy &= 6,193.3 + (-167.5) \\ &= 6,025.8 \end{aligned}$$

## Direct Data Entry

- Data then down-loaded to computer, ingested by the GIS software, and processed to form a spatial data layer.
- To date, surveying-based COGO has proven too expensive for most natural resource applications
- GPS (discussed later) increasingly common for COGO

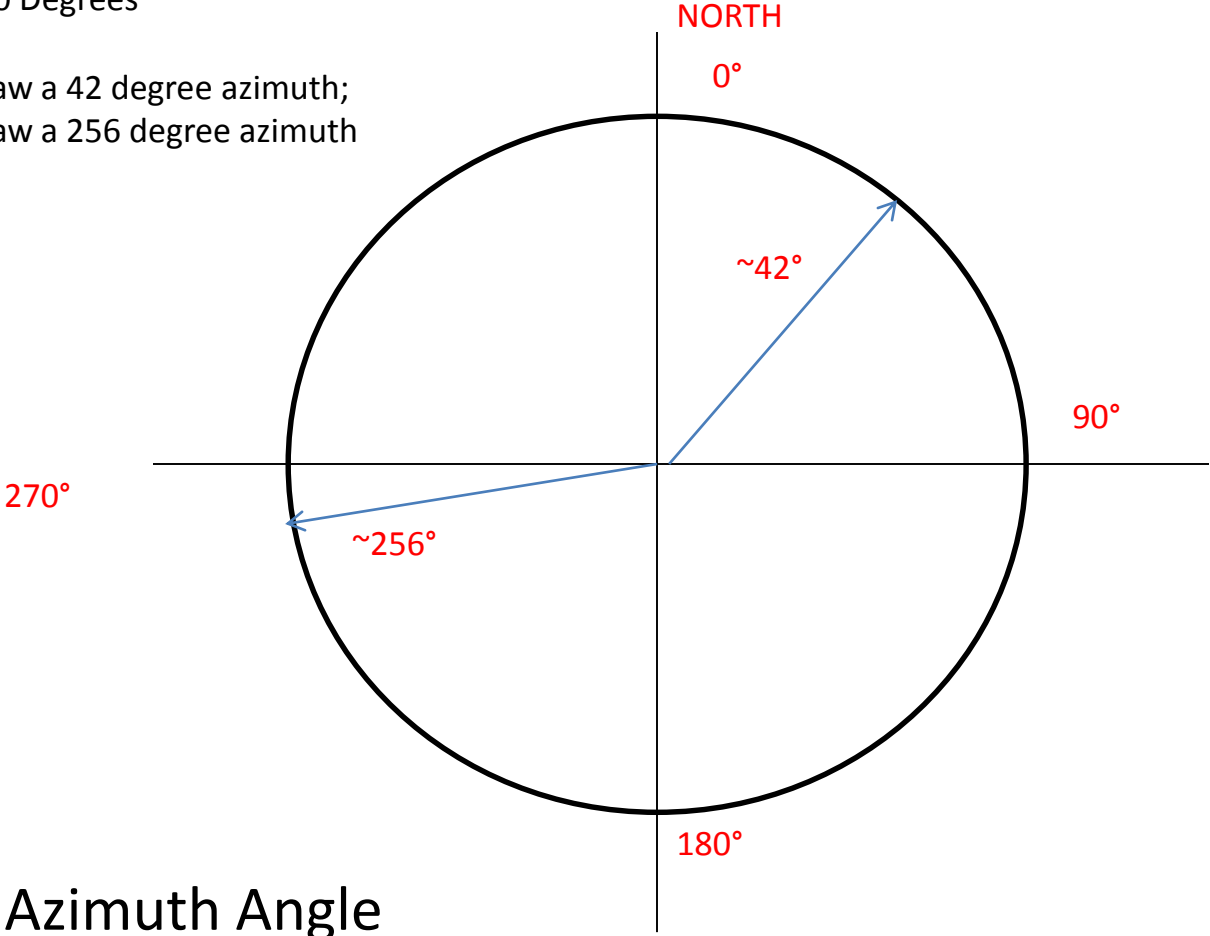
Label direction and 0, 90, 180 and 270 Degrees

Draw a 42 degree azimuth;  
Draw a 256 degree azimuth



Label direction and 0, 90, 180 and 270 Degrees

Draw a 42 degree azimuth;  
Draw a 256 degree azimuth



Azimuth Angle

**SOH - CAH - TOA**

It is pronounced "so - ka - toe - ah".

## **SOH - CAH - TOA**

It is pronounced "so - ka - toe - ah".

The SOH stands for "Sine of an angle is Opposite over Hypotenuse."  
The CAH stands for "Cosine of an angle is Adjacent over Hypotenuse."  
The TOA stands for "Tangent of an angle is Opposite over Adjacent."

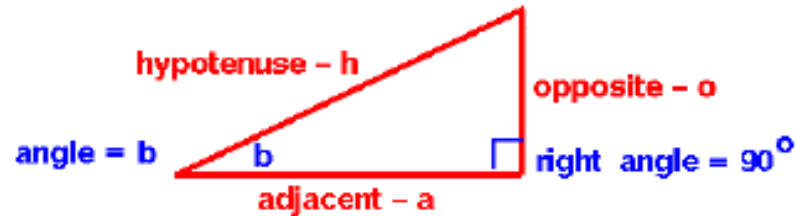


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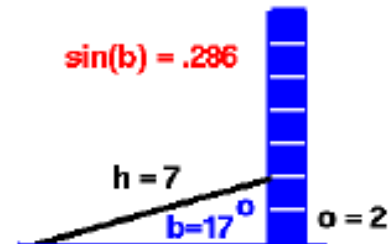
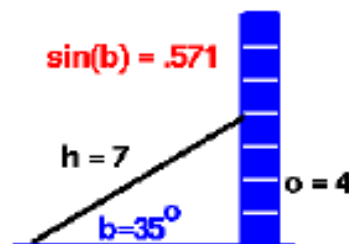
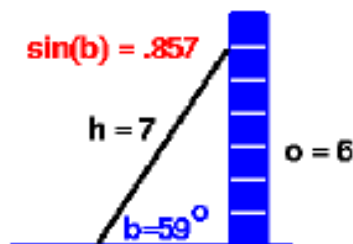
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The value of each ratio depends only on the size of the angle.



$$\text{sine } (a) = A/H$$

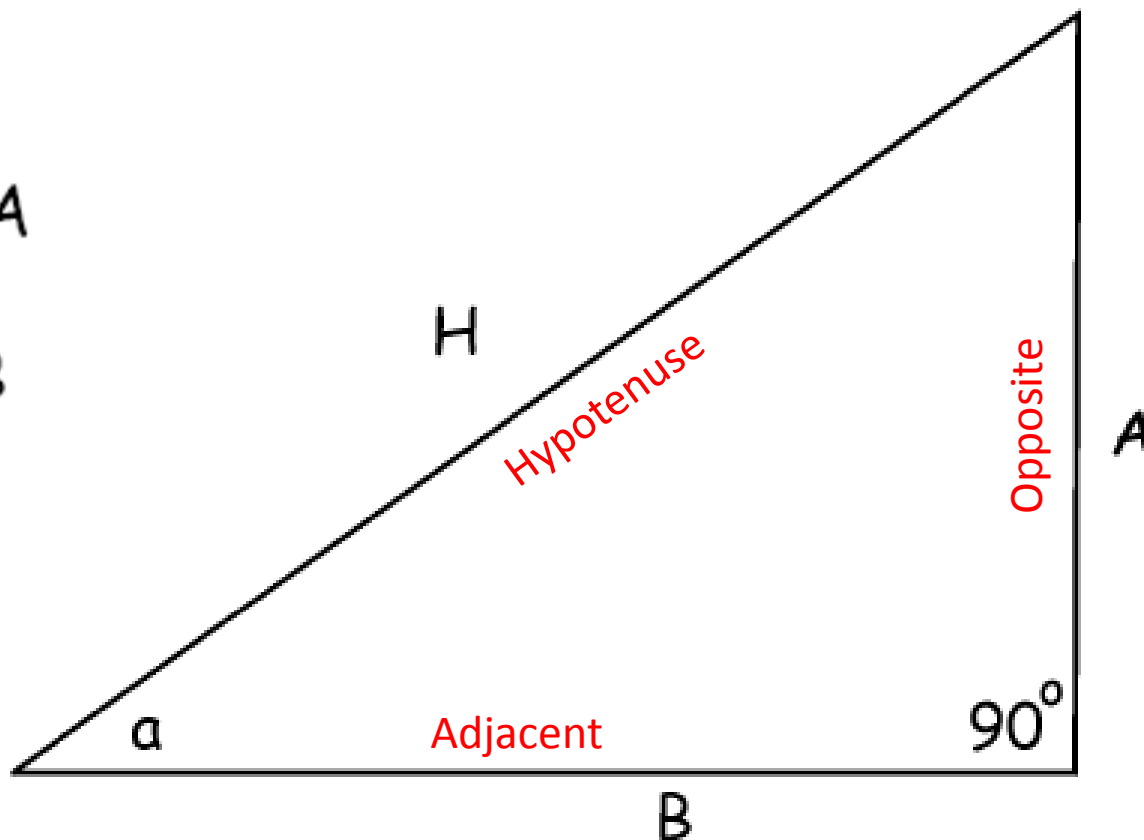
$$\text{cosine } (a) = B/H$$

$$\text{tangent } (a) = A/B$$

$$\text{cotangent } (a) = B/A$$

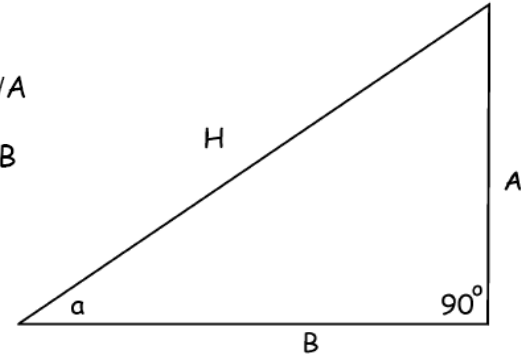
$$\text{secant } (a) = H/A$$

$$\text{cosecant } (a) = H/B$$



Since you know  
H (the hypotenuse or distance)  
And the angle "a" then

sine (a) = A/H  
cosine (a) = B/H  
tangent (a) = A/B  
cotangent (a) = B/A  
secant (a) = H/A  
cosecant (a) = H/B



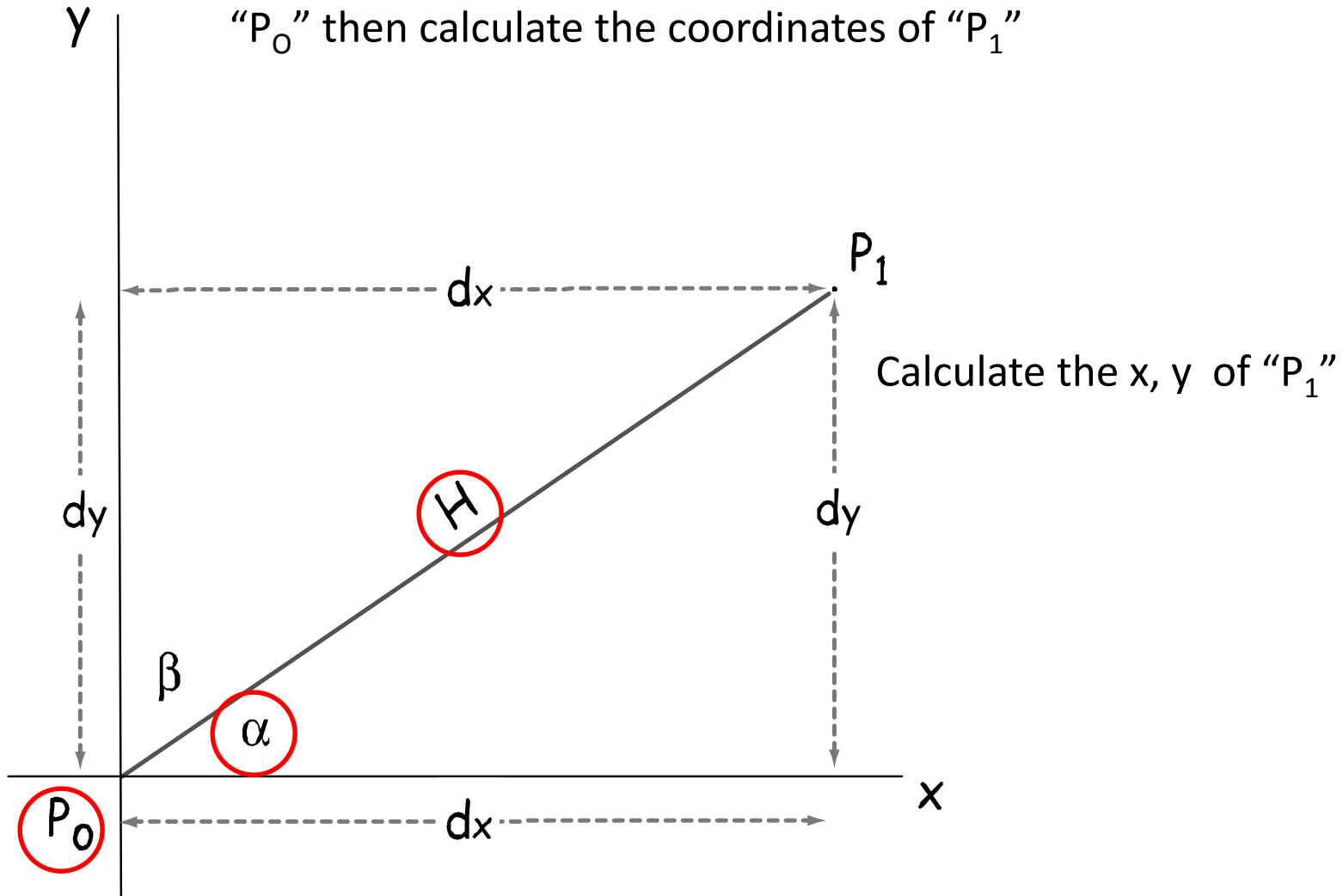
$$\text{Sine}(a) = A/H$$

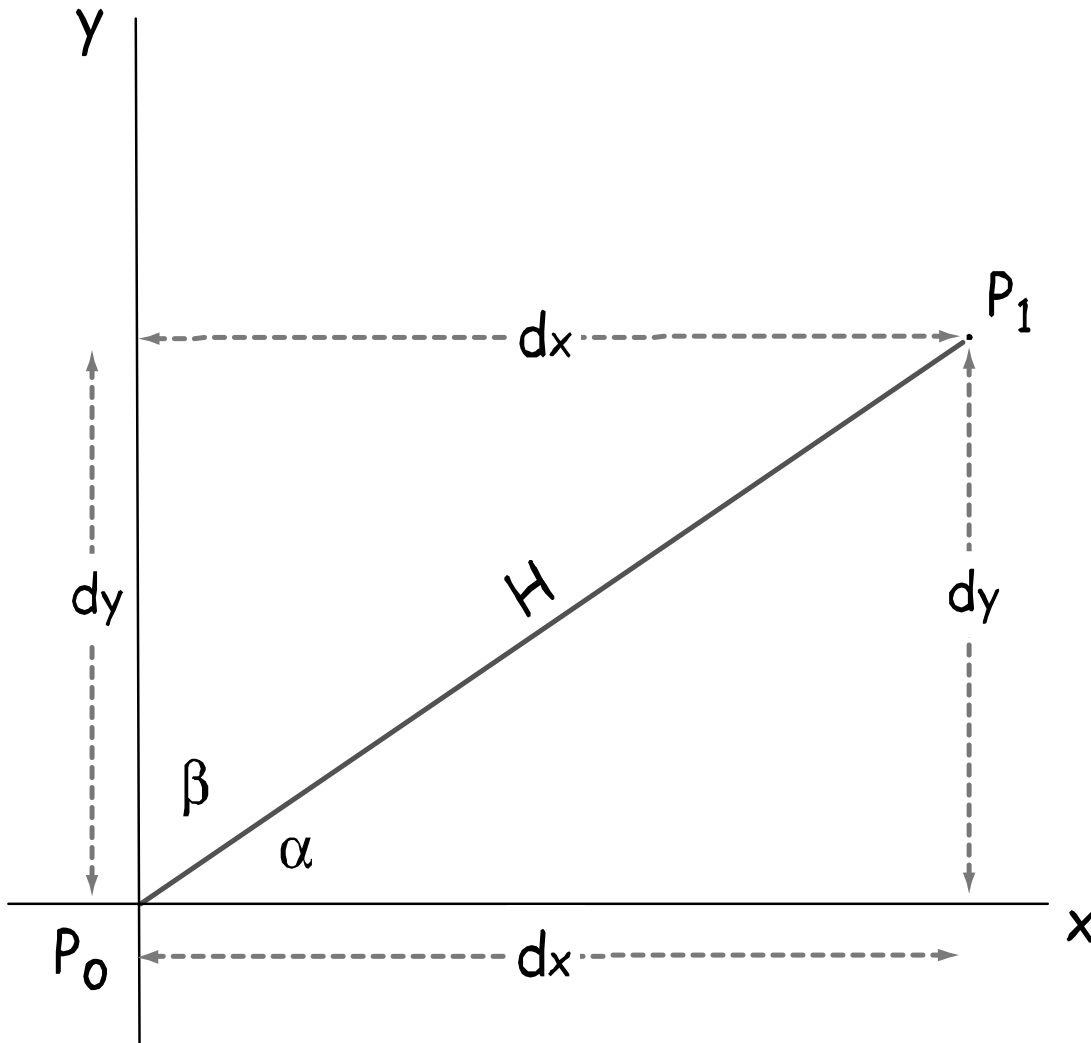
$$\text{Solve for A} \quad \rightarrow \quad \text{Sine}(a) \times H = A$$

$$\text{Cosine}(a) = B/H$$

$$\text{Solve for B} \quad \rightarrow \quad \text{Cosine}(a) \times H = B$$

Using COGO; if given an angle and distance from a point, "P<sub>0</sub>" then calculate the coordinates of "P<sub>1</sub>"





$$\alpha + \beta = 90^\circ$$

$$dy = H \cdot \sin(\alpha)$$

$$dy = H \cdot \cos(\beta)$$

$$dx = H \cdot \cos(\alpha)$$

$$dx = H \cdot \sin(\beta)$$

$$\text{if } \alpha + \beta = 90^\circ$$

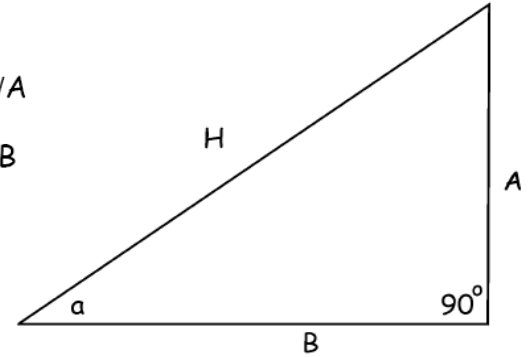
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cosine (a) = B/H  
tangent (a) = A/B  
cotangent (a) = B/A  
secant (a) = H/A  
cosecant (a) = H/B



$$\text{Sine}(a) = A/H$$

Solve for A →  $\text{Sine}(a) \times H = A$

$$\text{Cosine}(a) = B/H$$

Solve for B →  $\text{Cosine}(a) \times H = B$

Use Table or Calculator

Table of sin (angle)

Table of cos(angle)

Angle	sin (a)
0.0	0.0
1.0	.0174
2.0	.0349
3.0	.0523
4.0	.0698
5.0	.0872
6.0	.1045
7.0	.1219
8.0	.1392
9.0	.1564
10.0	.1736
11.0	.1908
12.0	.2079
13.0	.2249
14.0	.2419
15.0	.2588
16.0	.2756
17.0	.2924
18.0	.3090
19.0	.3256
20.0	.3420
21.0	.3584
22.0	.3746
23.0	.3907
24.0	.4067

Angle	sin (a)
25.0	.4226
26.0	.4384
27.0	.4540
28.0	.4695
29.0	.4848
30.0	.5000
31.0	.5150
32.0	.5299
33.0	.5446
34.0	.5592
35.0	.5736
36.0	.5878
37.0	.6018
38.0	.6157
39.0	.6293
40.0	.6428
41.0	.6561
42.0	.6691
43.0	.6820
44.0	.6947
45.0	.7071

Angle	sin (a)
46.0	.7193
47.0	.7314
48.0	.7431
49.0	.7547
50.0	.7660
51.0	.7772
52.0	.7880
53.0	.7986
54.0	.8090
55.0	.8191
56.0	.8290
57.0	.8387
58.0	.8480
59.0	.8571
60.0	.8660
61.0	.8746
62.0	.8829
63.0	.8910
64.0	.8988
65.0	.9063
66.0	.9135
67.0	.9205
68.0	.9272
69.0	.9336
70.0	.9397

Angle	sin (a)
71.0	.9455
72.0	.9511
73.0	.9563
74.0	.9613
75.0	.9659
76.0	.9703
77.0	.9744
78.0	.9781
79.0	.9816
80.0	.9848
81.0	.9877
82.0	.9903
83.0	.9926
84.0	.9945
85.0	.9962
86.0	.9976
87.0	.9986
88.0	.9994
89.0	.9998
90.0	1.00

Angle	cos(a)
0.0	1.00
1.0	.9998
2.0	.9994
3.0	.9986
4.0	.9976
5.0	.9962
6.0	.9945
7.0	.9926
8.0	.9903
9.0	.9877
10.0	.9848
11.0	.9816
12.0	.9781
13.0	.9744
14.0	.9703
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40.0	.7660
41.0	.7547
42.0	.7431
43.0	.7314
44.0	.7193
45.0	.7071

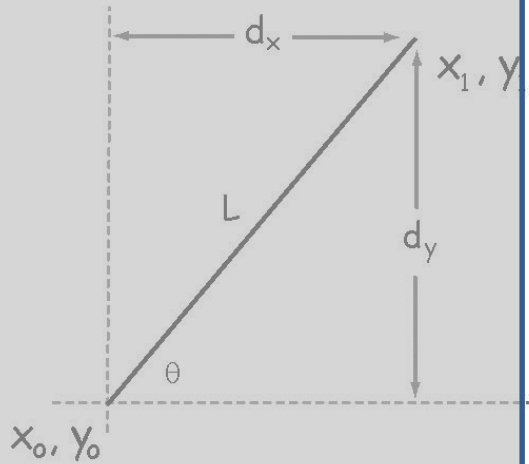
Angle	cos(a)
46.0	.6947
47.0	.6820
48.0	.6691
49.0	.6561
50.0	.6428
51.0	.6293
52.0	.6157
53.0	.6018
54.0	.5878
55.0	.5736
56.0	.5592
57.0	.5446
58.0	.5299
59.0	.5150
60.0	.5000
61.0	.4848
62.0	.4695
63.0	.4540
64.0	.4384
65.0	.4226
66.0	.4067
67.0	.3907
68.0	.3746
69.0	.3584
70.0	.3420

Angle	cos(a)
71.0	.3256
72.0	.3090
73.0	.2924
74.0	.2756
75.0	.2588
76.0	.2419
77.0	.2249
78.0	.2079
79.0	.1908
80.0	.1736
81.0	.1564
82.0	.1392
83.0	.1219
84.0	.1045
85.0	.0872
86.0	.0698
87.0	.0523
88.0	.0349
89.0	.0174
90.0	0.0

Lookup value for angle

# WORKSHEET

## Coordinate geometry (COGO)



$$x_1 = x_0 + d_x$$

$$y_1 = y_0 + d_y$$

$$d_x = L \cdot \cos(\theta)$$

$$d_y = L \cdot \sin(\theta)$$

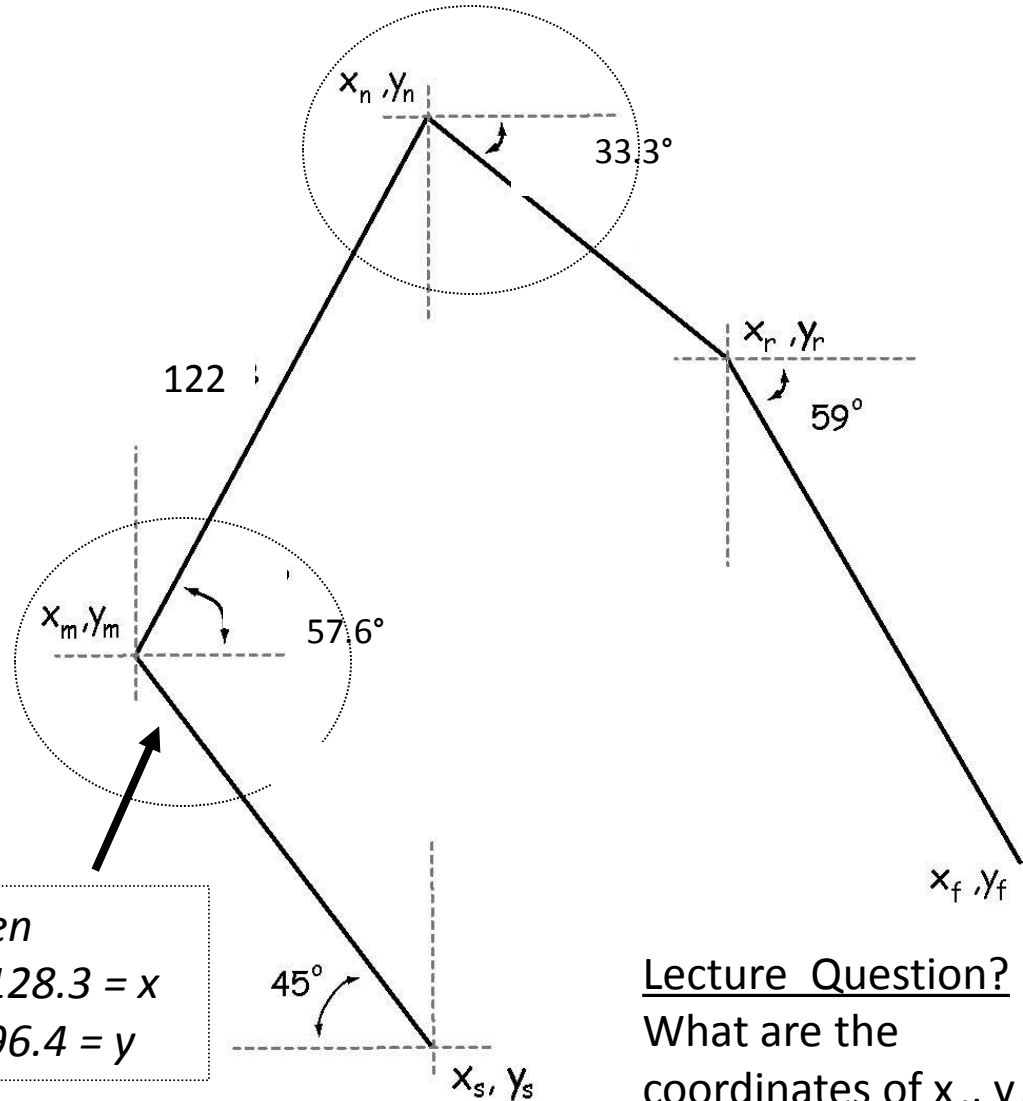
therefore

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## Traverse

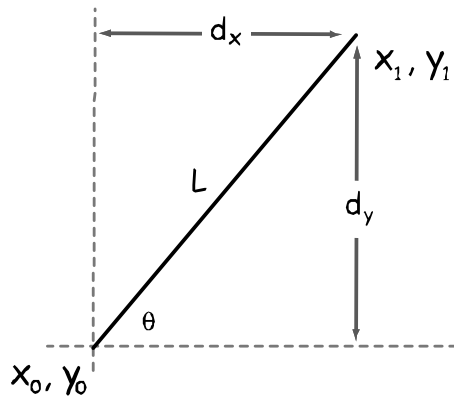
Name \_\_\_\_\_



**Given**  
 $10,128.3 = x$   
 $6,096.4 = y$

Lecture Question?  
 What are the coordinates of  $x_n, y_n$ ?

## Coordinate geometry (COGO)



$$x_1 = x_0 + d_x$$

$$y_1 = y_0 + d_y$$

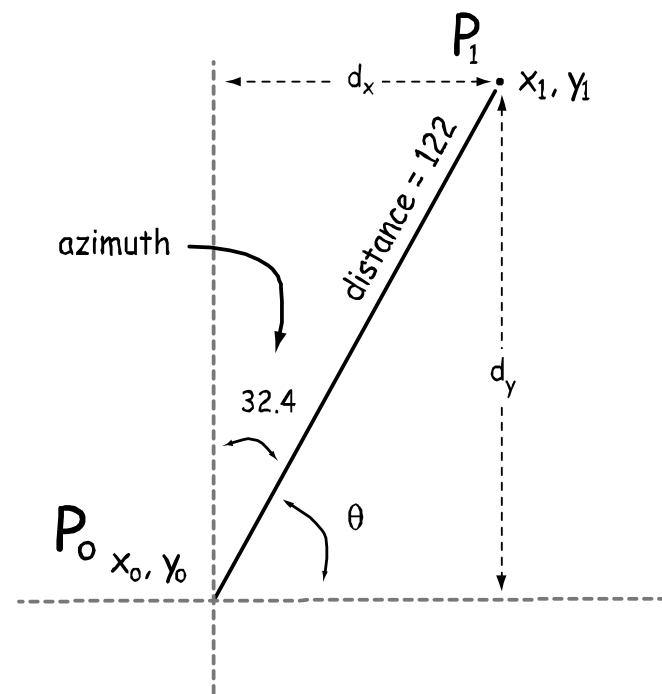
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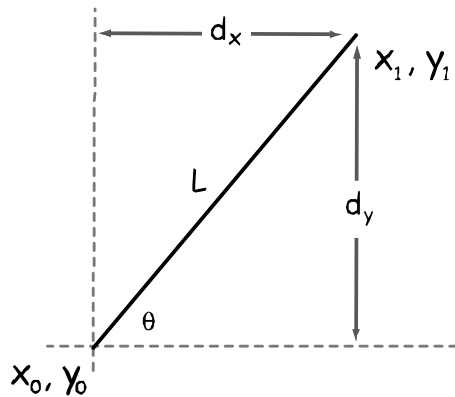
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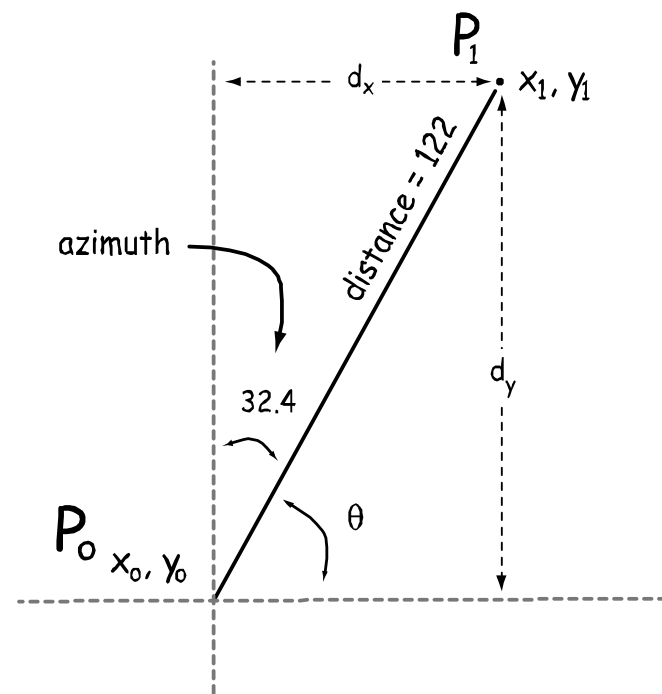
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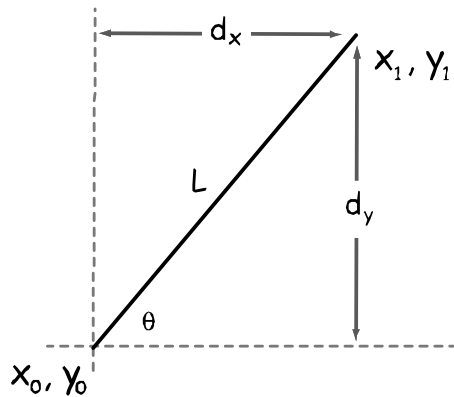
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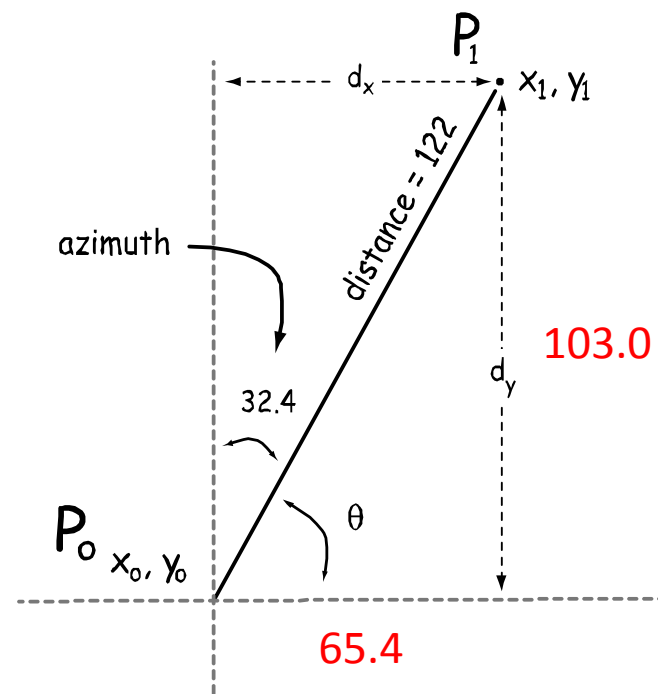
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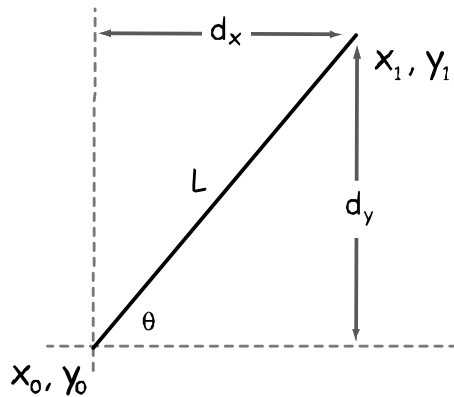


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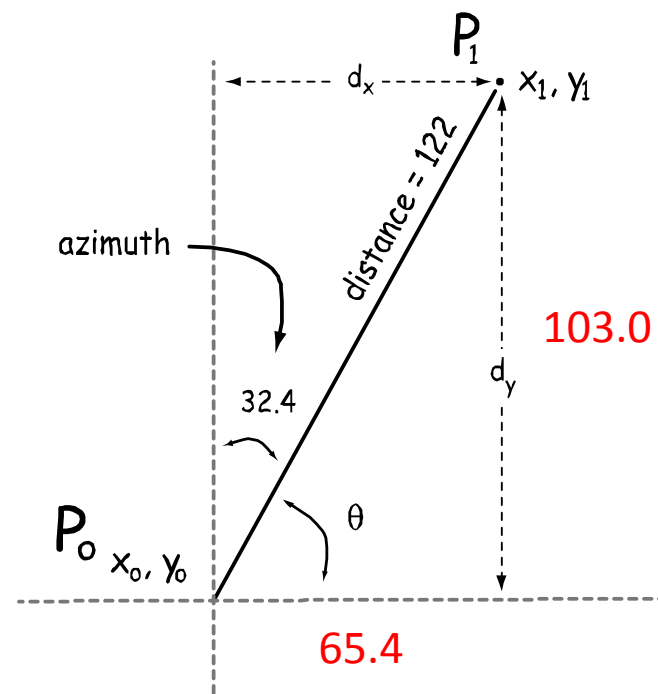
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$$x_1 = x_0 + L \cdot \cos(\theta)$$

$$y_1 = y_0 + L \cdot \sin(\theta)$$

Given  $x_0 = 10,128.3$  and  $y_0 = 6,096.4$ , the distance from  $P_0$  to  $P_1$  is measured at 122, and the azimuth angle from  $P_0$  to  $P_1$  is  $32.4^\circ$ ,

what are the coordinates  $x_1, y_1$  at point  $P_1$ ?



$$\theta = 90 - 32.4 = 57.6$$

$$\begin{aligned} dx &= L \cdot \cos(\theta) = 122 \cdot \cos(57.6) \\ &= 122 \cdot 0.535828 \\ &= 65.4 \end{aligned}$$

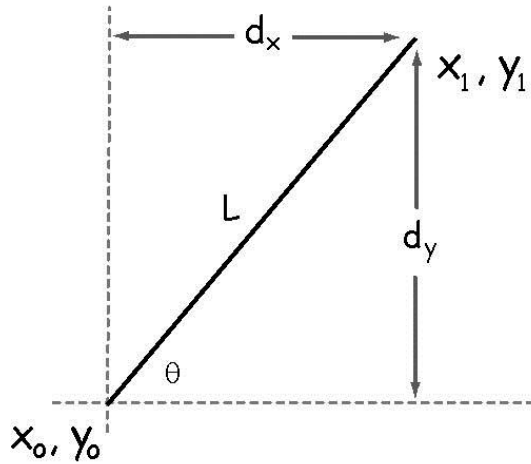
$$\begin{aligned} dy &= L \cdot \sin(\theta) = 122 \cdot \sin(57.6) \\ &= 122 \cdot 0.844327 \\ &= 103.0 \end{aligned}$$

$$\begin{aligned} x_1 &= x_0 + dx = 10,128.3 + 65.4 \\ &= 10,193.7 \end{aligned}$$

$$\begin{aligned} y_1 &= y_0 + dy = 6,096.4 + 103.0 \\ &= 6,199.4 \end{aligned}$$

# NEW QUESTION

## Coordinate geometry (COGO)



$$x_1 = x_0 + d_x$$

$$y_1 = y_0 + d_y$$

$$d_x = L \cdot \cos(\theta)$$

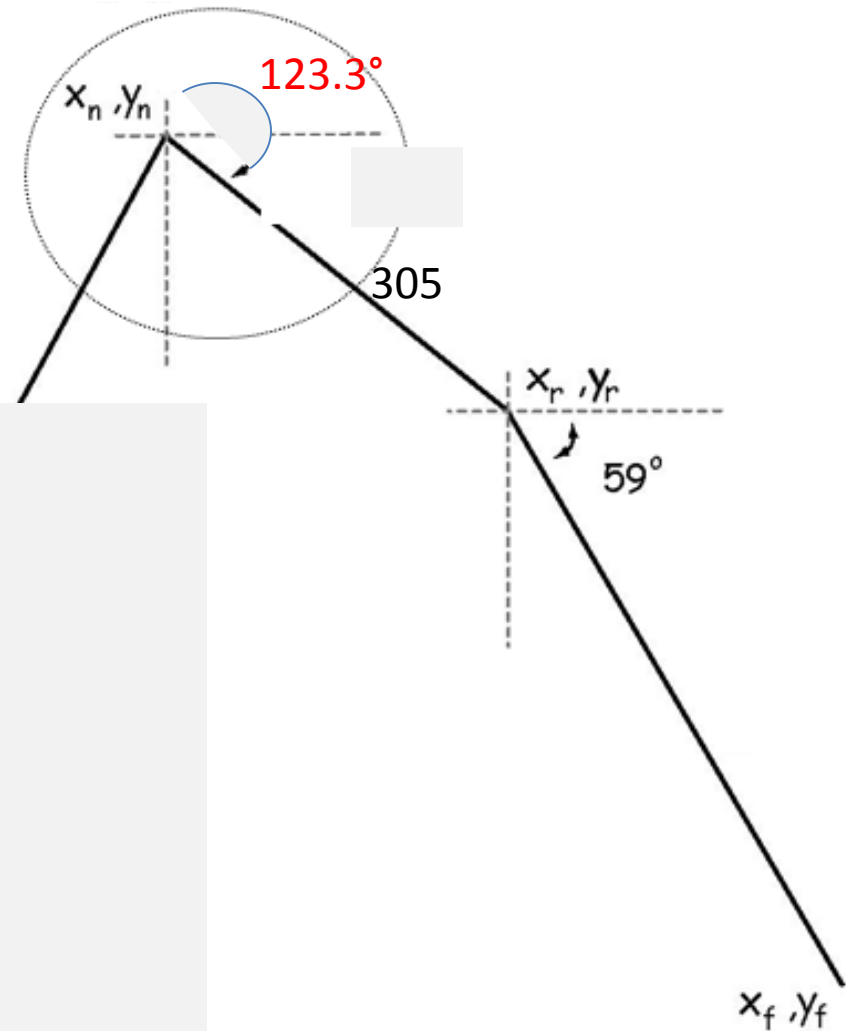
$$d_y = L \cdot \sin(\theta)$$

therefore

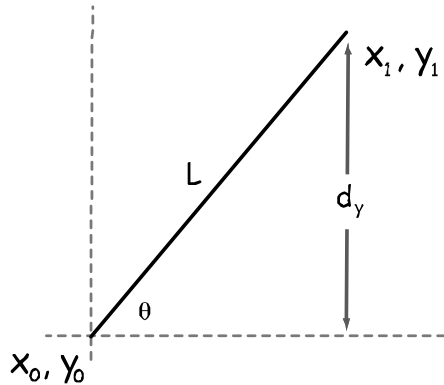
$$x_1 = x_0 + L \cdot \cos(\theta)$$

$$y_1 = y_0 + L \cdot \sin(\theta)$$

Given  $x_n = 10,400.6$  and  $y_n = 6,193.3$ , azimuth of  $123.3^\circ$  and distance of 305  
What is  $(x_r, y_r)$ ?



## Coordinate geometry (COGO)



$$x_1 = x_0 + dx$$

$$y_1 = y_0 + dy$$

$$dx = L \cdot \cos(\theta)$$

$$dy = L \cdot \sin(\theta)$$

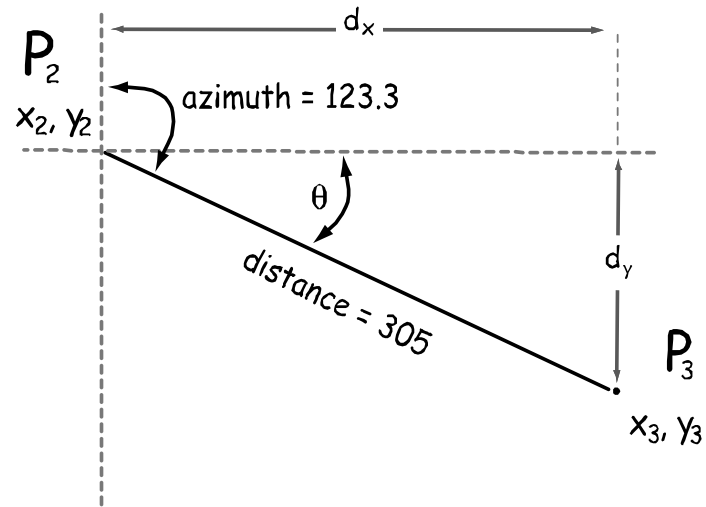
therefore

$$x_1 = x_0 + L \cdot \cos(\theta)$$

$$y_1 = y_0 + L \cdot \sin(\theta)$$

Given  $x_2 = 10,400.6$  and  $y_2 = 6,193.3$ , the distance from  $P_2$  to  $P_3$  is measured at 305, and the azimuth angle from  $P_2$  to  $P_3$  is  $123.3^\circ$ ,

what are the coordinates  $x_3, y_3$  at point  $P_3$ ?



$$\theta = 123.3 - 90 = 33.3$$

$$\begin{aligned} \text{then } L \cdot \cos(\theta) &= 305 \cdot \cos(33.3) \\ &= 305 \cdot 0.835808 \\ &= 254.9 \end{aligned}$$

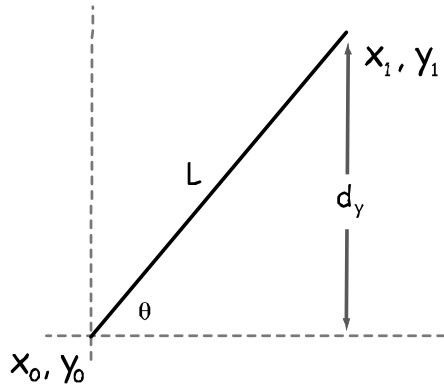
note,  $dy$  is negative, so  $dy$  is

$$\begin{aligned} -L \cdot \sin(\theta) &= -305 \cdot \sin(33.3) \\ &= -305 \cdot 0.054902 \\ &= -167.5 \end{aligned}$$

$$\begin{aligned} x_3 = x_2 + dx &= 10,400.6 + 254.9 \\ &= 10,655.5 \end{aligned}$$

$$\begin{aligned} y_3 = y_2 + dy &= 6,193.3 + (-167.5) \\ &= 6,025.8 \end{aligned}$$

### Coordinate geometry (COGO)



$$x_1 = x_0 + dx$$

$$y_1 = y_0 + dy$$

$$dx = L \cdot \cos(\theta)$$

$$dy = L \cdot \sin(\theta)$$

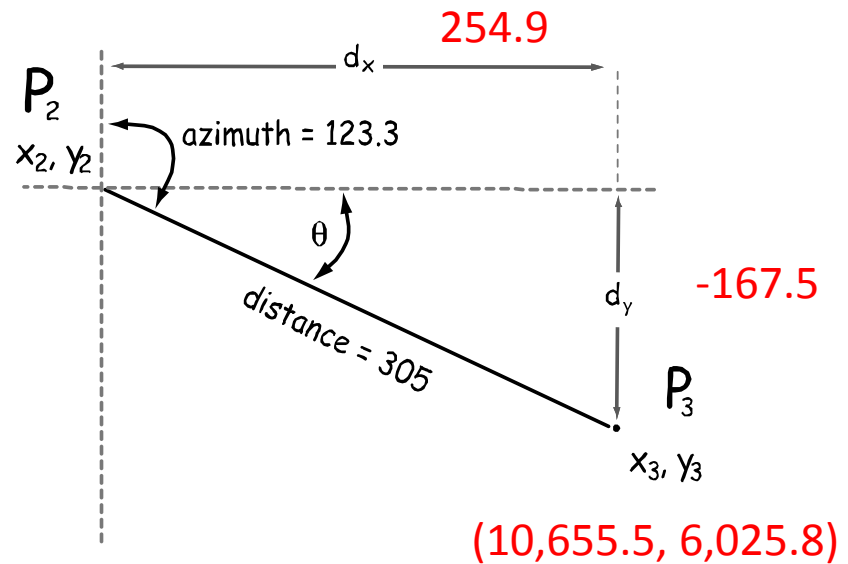
therefore

$$x_1 = x_0 + L \cdot \cos(\theta)$$

$$y_1 = y_0 + L \cdot \sin(\theta)$$

Given  $x_2 = 10,400.6$  and  $y_2 = 6,193.3$ , the distance from  $P_2$  to  $P_3$  is measured at 305, and the azimuth angle from  $P_2$  to  $P_3$  is  $123.3^\circ$ ,

what are the coordinates  $x_3, y_3$  at point  $P_3$ ?



$$\theta = 123.3 - 90 = 33.3$$

$$\begin{aligned} \text{then } L \cdot \cos(\theta) &= 305 \cdot \cos(33.3) \\ &= 305 \cdot 0.835808 \\ &= 254.9 \end{aligned}$$

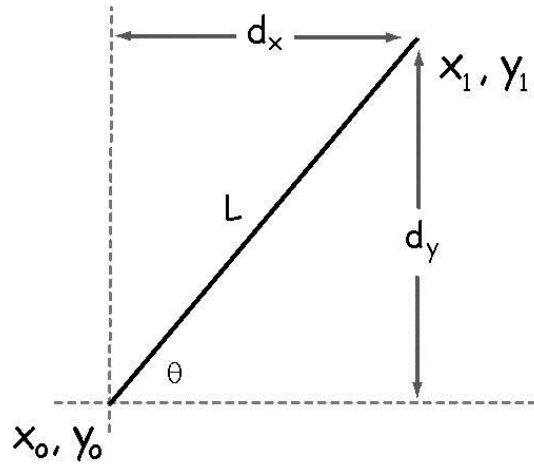
note,  $dy$  is negative, so  $dy$  is

$$\begin{aligned} -L \cdot \sin(\theta) &= -305 \cdot \sin(33.3) \\ &= -305 \cdot 0.54902 \\ &= -167.5 \end{aligned}$$

$$\begin{aligned} x_3 = x_2 + dx &= 10,400.6 + 254.9 \\ &= 10,655.5 \end{aligned}$$

$$\begin{aligned} y_3 = y_2 + dy &= 6,193.3 + (-167.5) \\ &= 6,025.8 \end{aligned}$$

## Coordinate geometry (COGO)



$$x_1 = x_0 + d_x$$

$$y_1 = y_0 + d_y$$

$$d_x = L \cdot \cos(\theta)$$

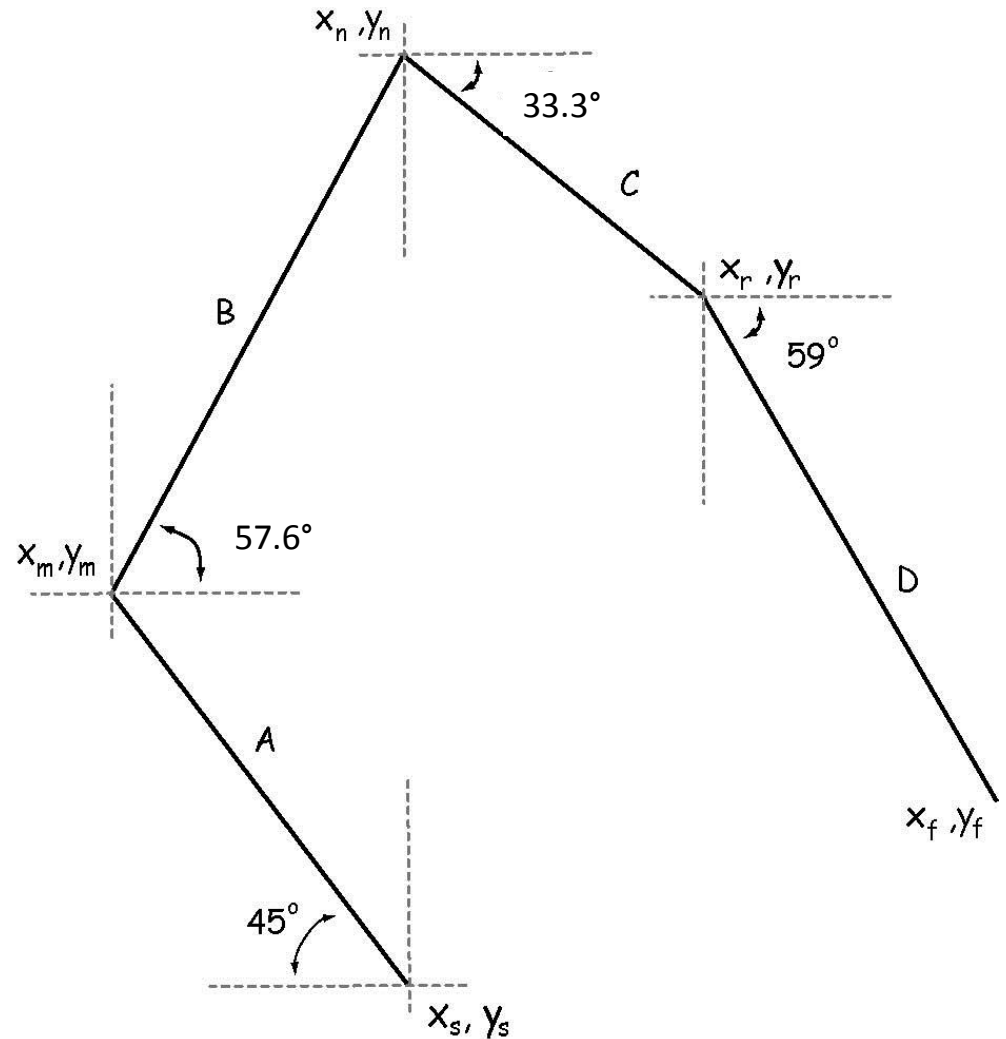
$$d_y = L \cdot \sin(\theta)$$

therefore

$$x_1 = x_0 + L \cdot \cos(\theta)$$

$$y_1 = y_0 + L \cdot \sin(\theta)$$

## Traverse



Study Question on Page 210, Bolstad 2008, *GIS Fundamentals*

**Starting at point X = 10,128.3, Y = 6,096.4**

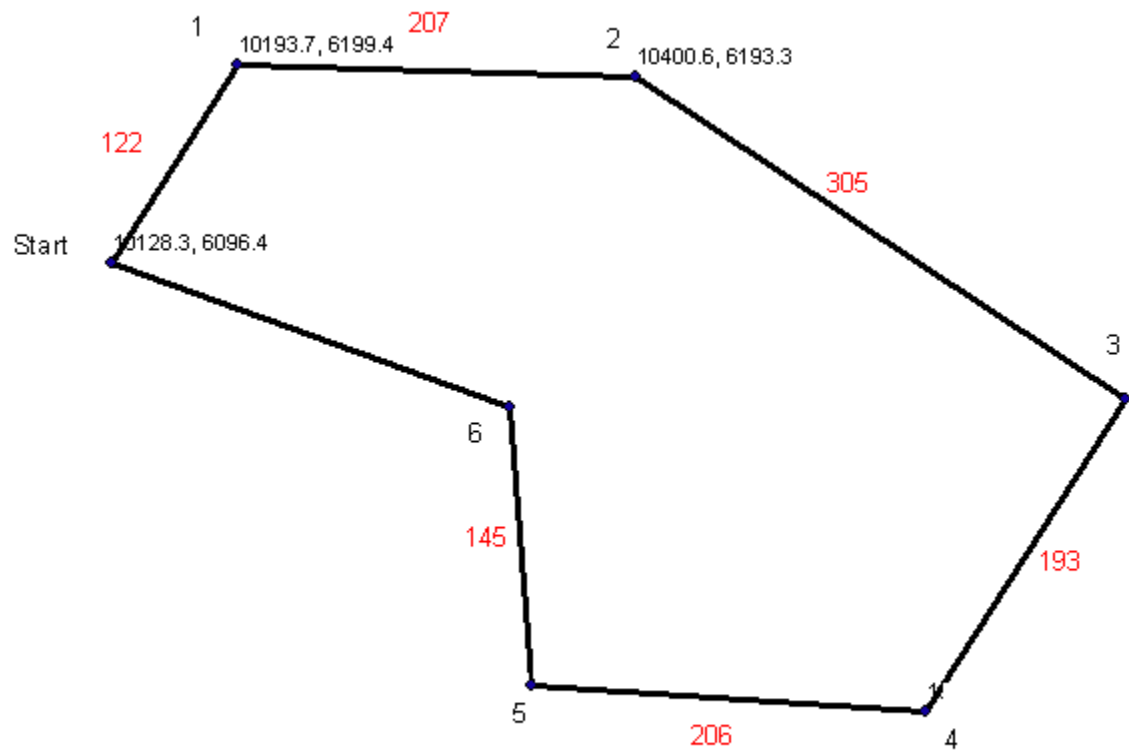
	Azimuth	Distance	Delta X	Delta Y	X	Y
					10128.3	6096.4
P1	32.4	122	65.4	103.0	10193.7	6199.4
P2	91.7	207	206.9	-6.1	10400.6	6193.3
P3	123.3	305				
P4	212.5	193				
P5	273.9	206				
P6	355.5	145	-60.1	131.9	10,334.9	6,021.6



Study Question on Page 157, Bolstad 2005, *GIS Fundamentals*

**Starting at point X = 10,128.3, Y = 6,096.4**

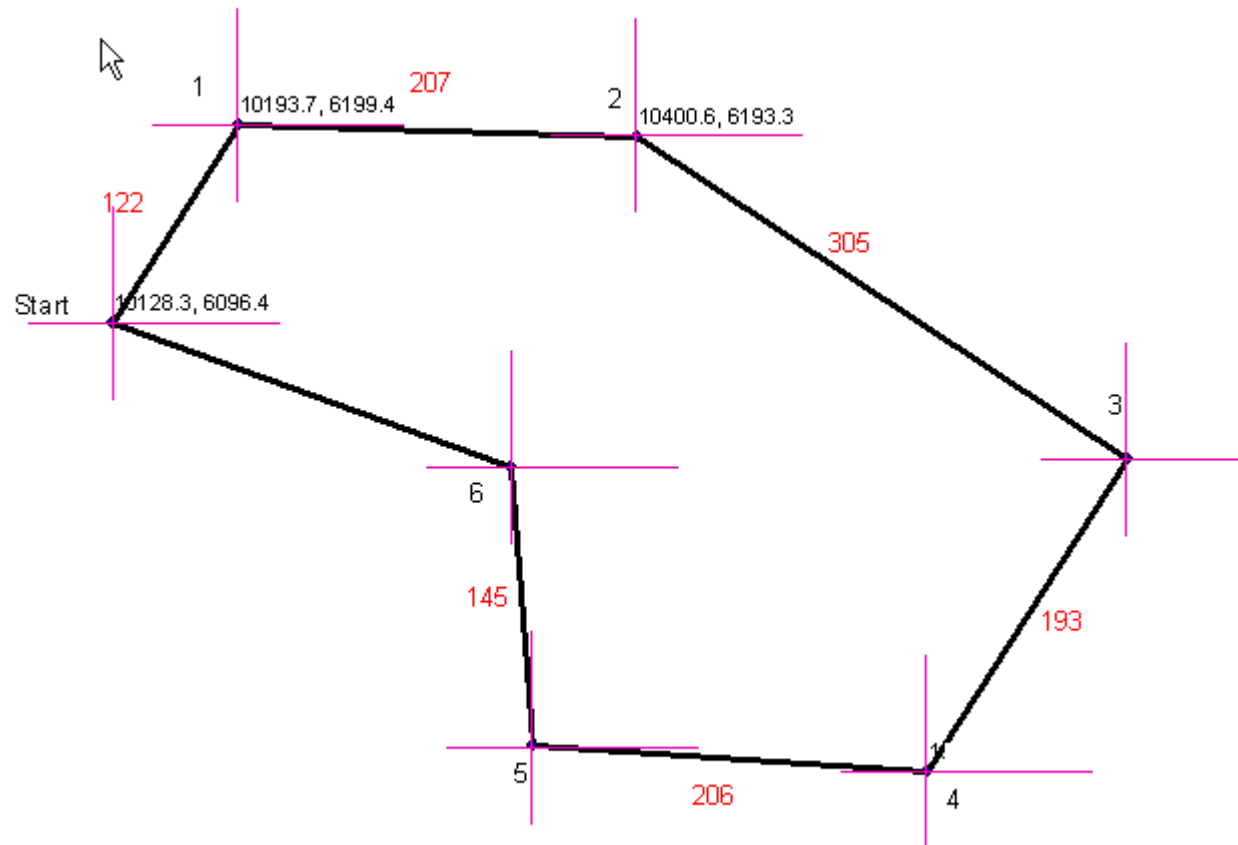
	Azimuth	Distance	Delta X	Delta Y	X	Y
					10128.3	6096.4
P1	32.4	122	65.4	103.0	10193.7	6199.4
P2	91.7	207	206.9	-6.1	10400.6	6193.3
P3	123.3	305				
P4	212.5	193				
P5	273.9	206				
P6	355.5	145	-11.4	144.6	10334.9	6021.6



Study Question on Page 157, Bolstad 2005, *GIS Fundamentals*

**Starting at point X = 10,128.3, Y = 6,096.4**

	Azimuth	Bearing	Distance	Delta X	Delta Y	X	Y
						10128.3	6096.4
P1	32.4	57.6	122	65.4	103.0	10193.7	6199.4
P2	91.7	1.7	207	206.9	-6.1	10400.6	6193.3
P3	123.3	33.3	305				
P4	212.5	57.5	193				
P5	273.9	3.9	206				
P6	355.5	85.5	145	-11.4	144.6	10334.9	6021.6



Study Question on Page 210, Bolstad 2008, *GIS Fundamentals*

**Starting at point X = 10,128.3, Y = 6,096.4**

	Azimuth	Quadrant	Bearing	Distance		calc X		calc Y	Delta X	Delta Y	X	Y
											10128.3	6096.4
P1	32.4	0	57.6	122	1	10193.7	1	6199.4	65.4	103.0	10193.7	6199.4
P2	91.7	90	1.7	207	1	10400.6	-1	6193.3	206.9	-6.1	10400.6	6193.3
P3	123.3	90	33.3	305	1	10655.5	-1	6025.8	254.9	-167.5	10655.5	6025.8
P4	212.5	270	57.5	193	-1	10551.8	-1	5863.0	-103.7	-162.8	10551.8	5863.0
P5	273.9	270	3.9	206	-1	10346.3	1	5877.1	-205.5	14.0	10346.3	5877.1
P6	355.5	270	85.5	145	-1	10334.9	1	6021.6	-11.4	144.6	10334.9	6021.6

