POLITEKNIK MALAYSIA

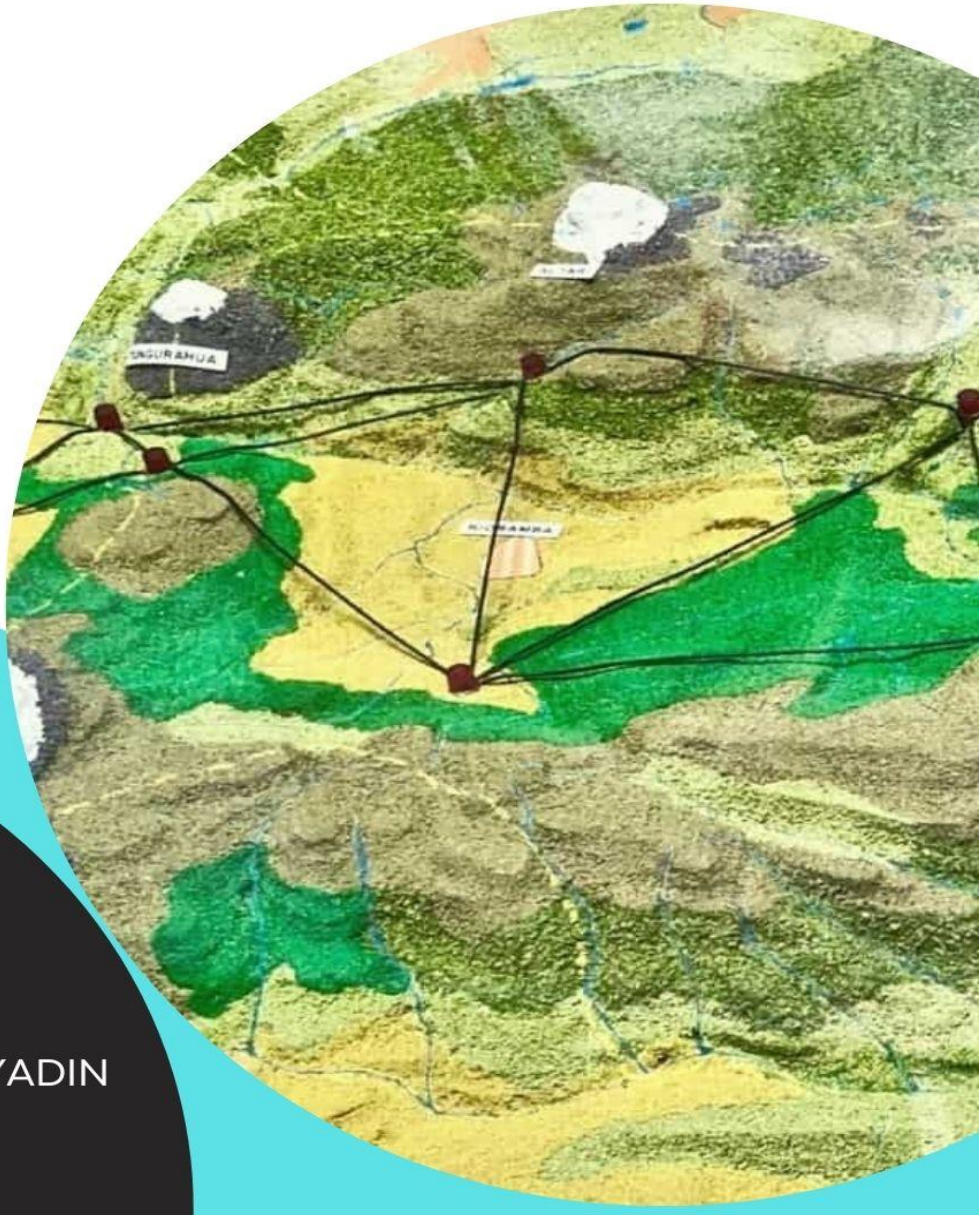
KEMENTERIAN PENGAJIAN TINGGI

KOLEJ KOMUNITI MALAYSIA

Basic Computation

in Cadastral Surveying

Volume 1



by

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NURUL AZUWA MD MUHAYADIN

MUSTAQIIMAH MUHAMAD

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Preface

In the name of Allah the Most Merciful

Alhamdulillah, be grateful to God for His grace
to complete a note for the teaching and learning process
for polytechnic students of the Diploma Geomatics
Programme
for the Surveying Computation course.

Synopsis

SURVEYING COMPUTATION equips students with knowledge and understanding in problem solving related to the calculations of traverse. It also provides early exposure to students about concept of bearing and angle, trigonometry and three point problems. The course emphasizes on calculation for surveying works. Students are also exposed with the knowledge of area division for a closed traverse.

Topic Pages

Topic 1: Bearing and Angle
Topic 2: Trigonometry

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Topic 1: Bearing and Angle

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- 1.1.4 Calculate the internal angle from two bearings
- 1.1.5 Calculate the bearing from internal angle and a known bearing

Topic 2: Trigonometry

2.1. Apply the concept of trigonometric function in survey problems
- 2.1.1 Solve the triangle problems using sine and cosine formula for triangle

TOPIC 1:

Bearing and angle

1.1 Determine bearing and angle conversion

1.1.1 Differentiate between terms of bearing and angle
1.1.2 Differentiate between terms of bearing and whole circle bearing
1.1.3 Compute whole circle bearing conversion to quadrant bearing
1.1.4 Calculate the internal angle from two bearings
1.1.5 Calculate the bearing from internal angle and a known bearing

1.1.1 Differentiate between terms of bearing and angle

In land surveying, the direction of one station to another station determined by reading a bearing. Bearing of line is horizontal angle between one reference direction or meridian with the line. Figure 1.0 shows the example of reading bearing for a line.

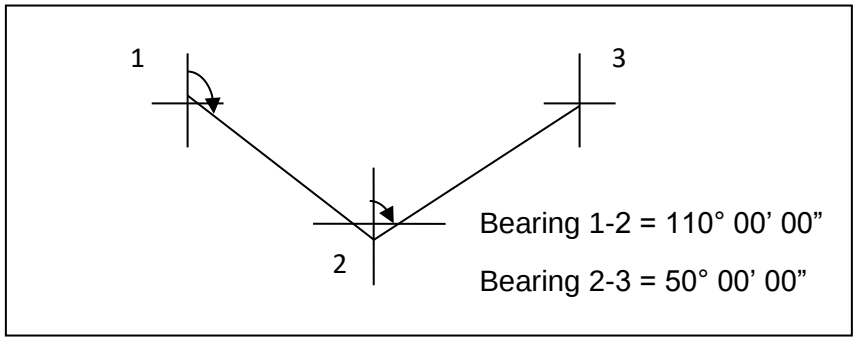


Figure 1.0 Reading bearing for a line

The bearing is whole circle bearing read in angle manner; degree (°), minutes (‘) and second (“). One whole circle bearing is 360°. One whole circle bearing divided to four quadrants. Figure 1.1 shows the earlier explanation.

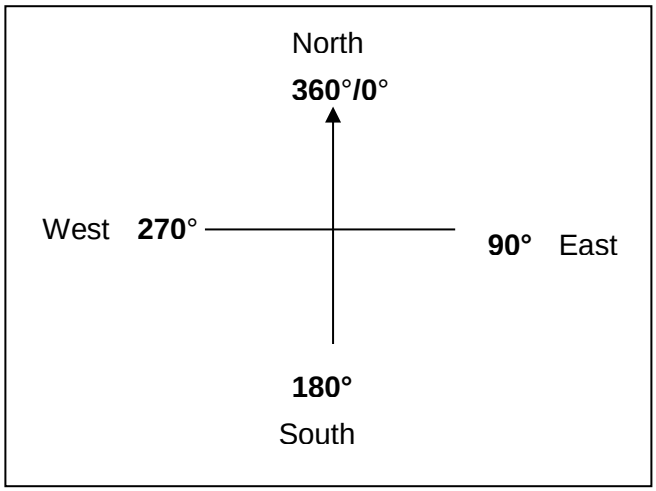


Figure 1.1 Quadrant of bearing

Angle is two or more survey line observed in one station so exist the angle for the station. Figure 1.3 shows angle can be determined.

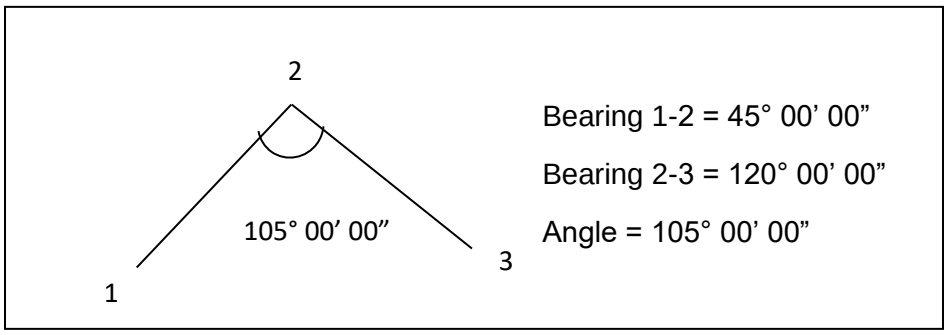


Figure 1.3 Determination an angle

1.1.2 Differentiate between terms of bearing and whole circle bearing

Bearing is reading clockwise from True North start from 0°. Bearing is reading from 1 point to another point according to reference. Bearing from 1 point to another point is reading continuously from station 1 to 2, 2 to 3, 3 to 4 and until station 25 if the survey area is wide and close the traverse by sun observation. So station 1 to 2 is called fore bearing. When we change the equipment to next station, the back bearing of previous station is 2 to 1. The different of two bearing is 180° either way to add or substact 180°. The example of bearing read as shown below in Figure 1.4.

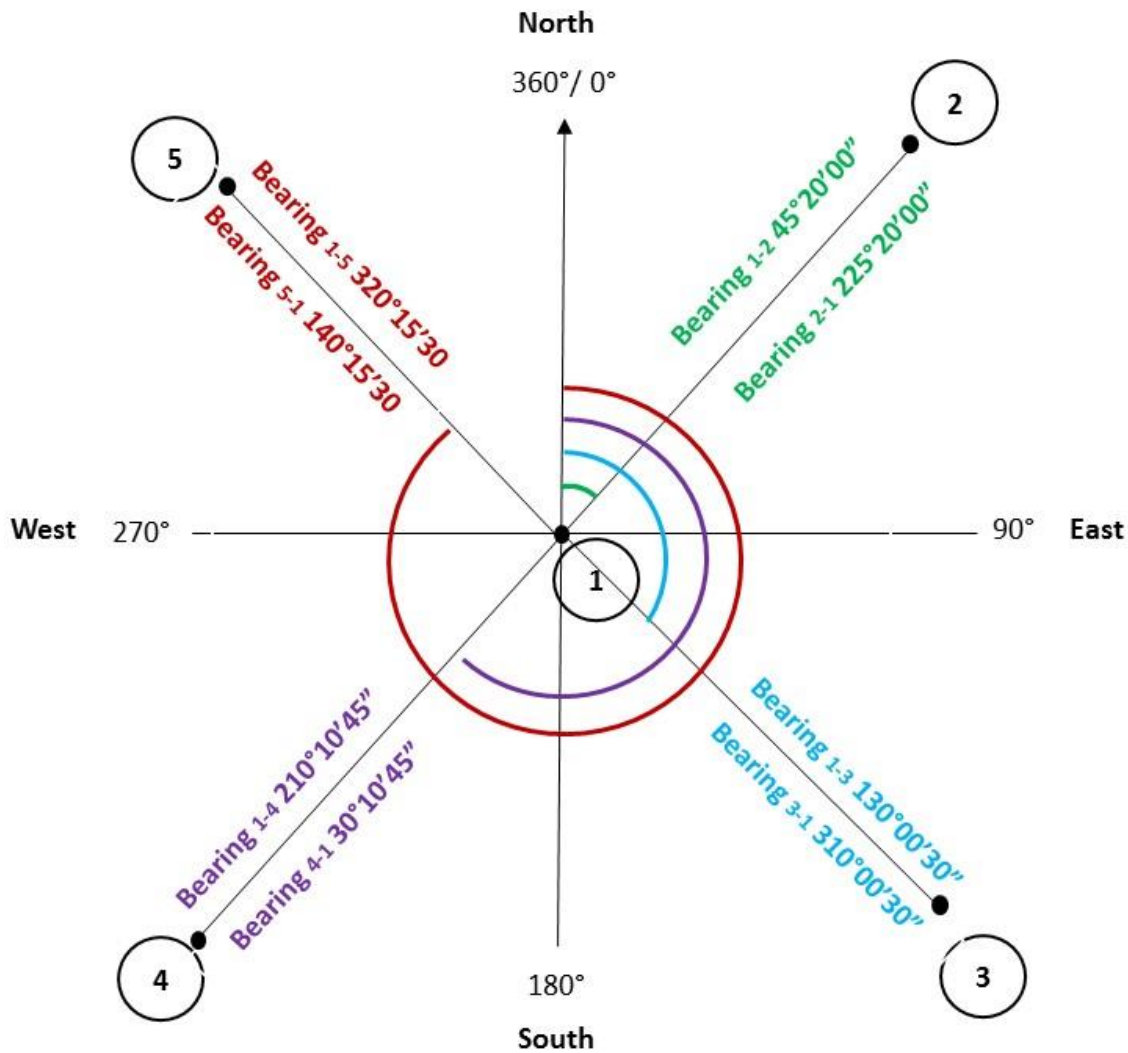
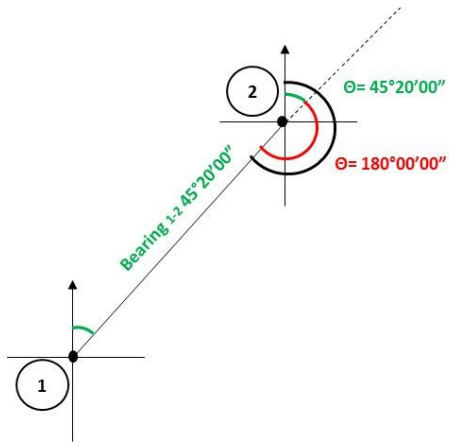
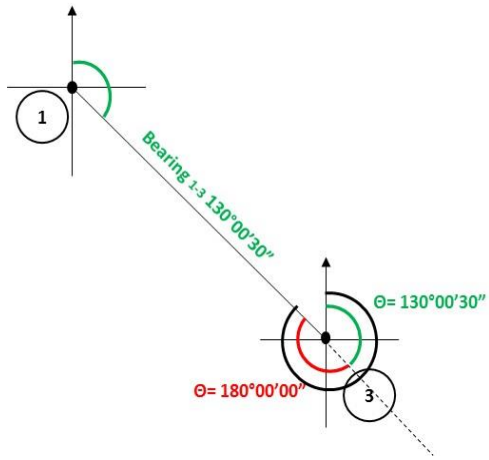
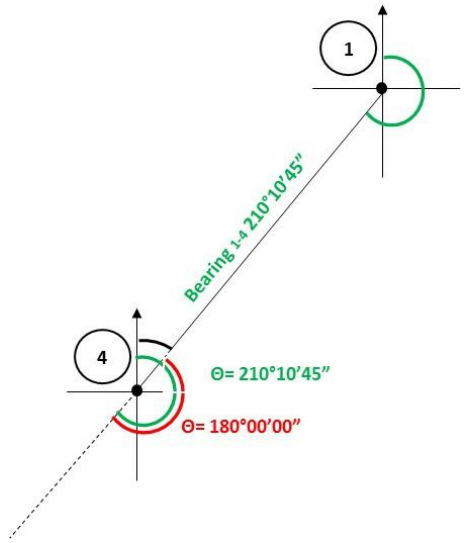
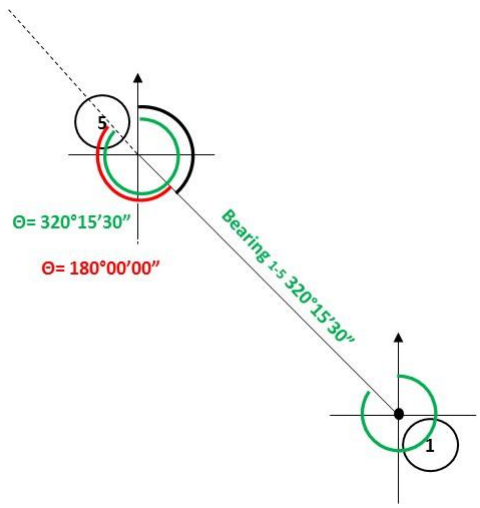


Figure 1.4 Fore Bearing & Back Bearing

Table 1.0 Example of how to determine fore bearing and back bearing

Station	Fore Bearing	Figure	Back Bearing
1-2	**45° 20’ 00”**		**225° 20’ 00”** (45° 20’ 00” + 180° = 225° 20’ 00”)
1-3	**130° 00’ 30”**		**310° 00’ 30”** (130° 00’ 30” + 180° = 310° 00’ 30”)
1-4	**210° 10’ 45”**		**30° 10’ 45”** (210° 10’ 45” - 180° = 30° 10’ 45”)

1-5	**320° 15’ 30”**		**140° 15’ 30”** (320° 15’ 30” - 180° = 140° 15’ 30”)

1.1.3 Compute whole circle bearing conversion to quadrant bearing

Bearing is performed two way to read. Whole circle bearing read from True North and read clockwise. For example 0° to 360°. While Quadrant bearing is acute angle read between face line to North or South direction. Quadrant bearing read 0°-90° at any quadrant. In other words, read by it's own quadrant where it's lays. For example bearing from quadrant I and IV, bearing read 0° to 90° from North to East and North to West. While for Quadrant II and III, bearing read 0° to 90° from South to East and South to West.

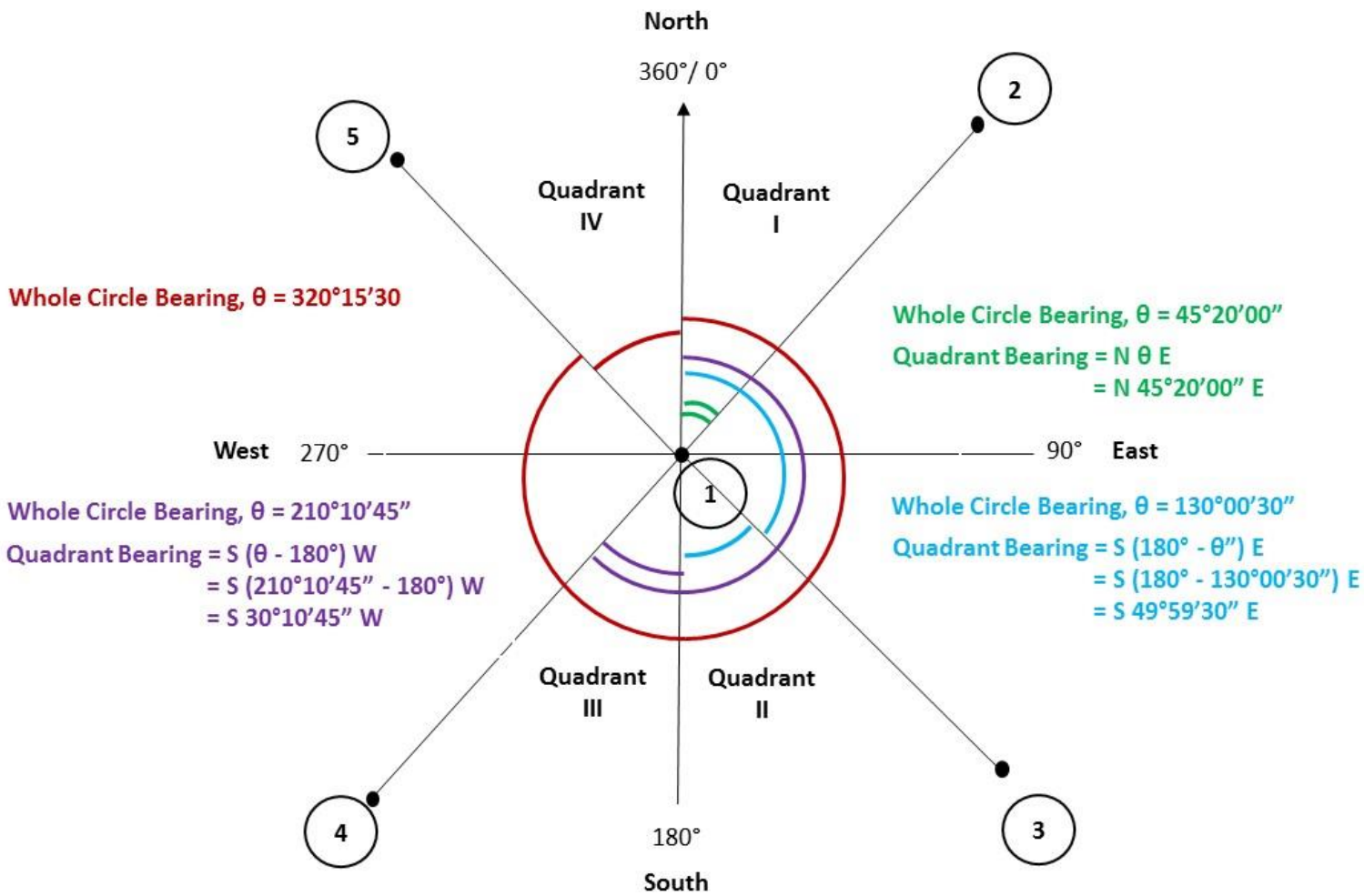
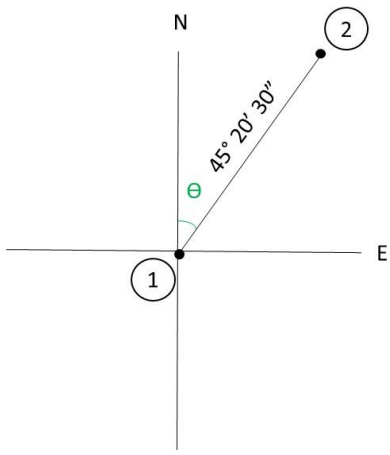
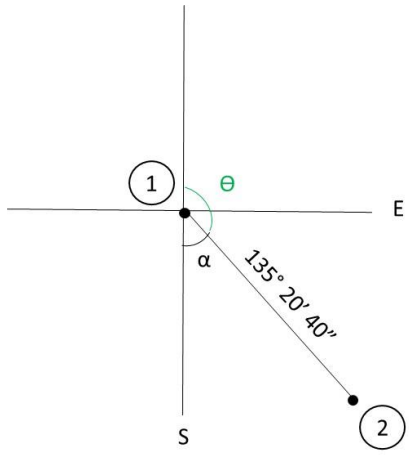
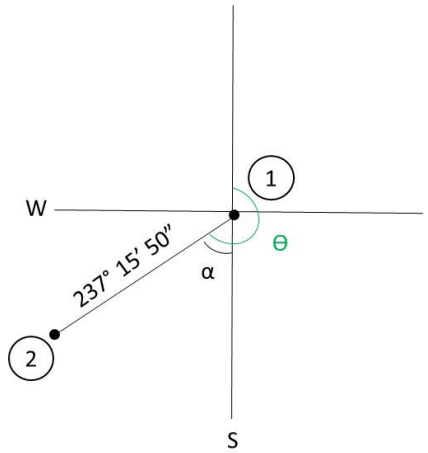


Figure 1.5

Table 1.1 Example of how to convert bearing from Whole Circle Bearing to Quadrant Bearing

Whole Circle Bearing	Figure	Quadrant Bearing
45° 20’ 30”		= N ϴ E = N 45° 20’ 30 E
135° 20’ 40”		= S (180° 00’ 00” - ϴ)E = S (180° 00’ 00” - 135° 20’ 40”) E = S 44° 39’ 20” E
237° 15’ 50”		= S (ϴ - 180° 00’ 00”)W = S (237° 15’ 50” - 180° 00’ 00”) W = S 57° 15’ 50” W

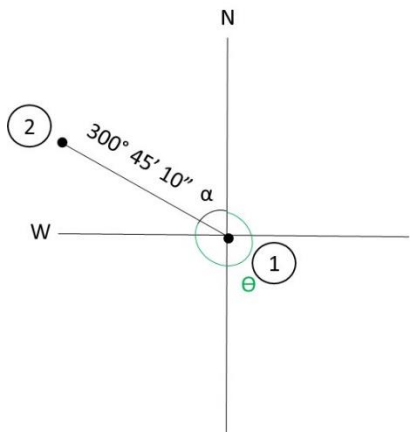
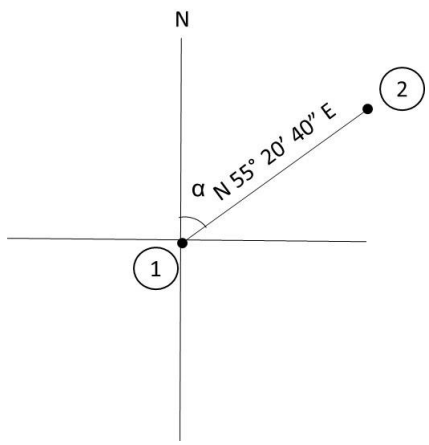
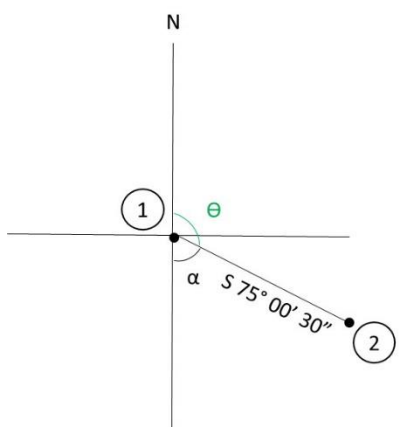
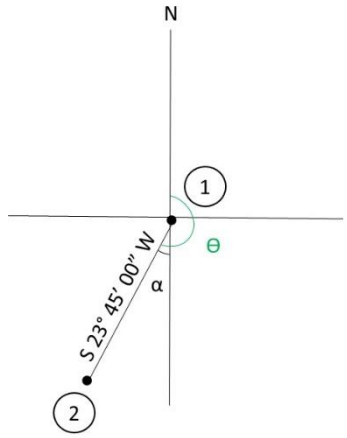
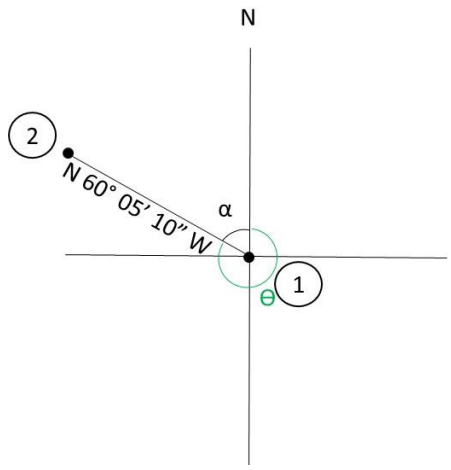
320° 15’ 30”		= N (360° 00’ 00” - ϴ)W = N (360° 00’ 00” - 300° 45’ 10”) W = N 57° 15’ 50” W

Table 1.2 Example of how to convert bearing from Quadrant Bearing to Whole Circle Bearing

Quadrant Bearing	Figure	Whole Circle Bearing
45° 20’ 30”		= α = 55° 20’ 40
		= 180° 00’ 00” - α = 180° 00’ 00” - 75° 00’ 30” = 104° 59’ 30”

237° 15’ 50”		= 180° 00’ 00” + α = 180° 00’ 00” + 23° 45’ 00” = 203° 45’ 00”
320° 15’ 30”		= 360° 00’ 00” - α = 360° 00’ 00” - 60° 05’ 10” = 299° 54’ 50”

1.1.4 Calculate the internal angle from two bearings

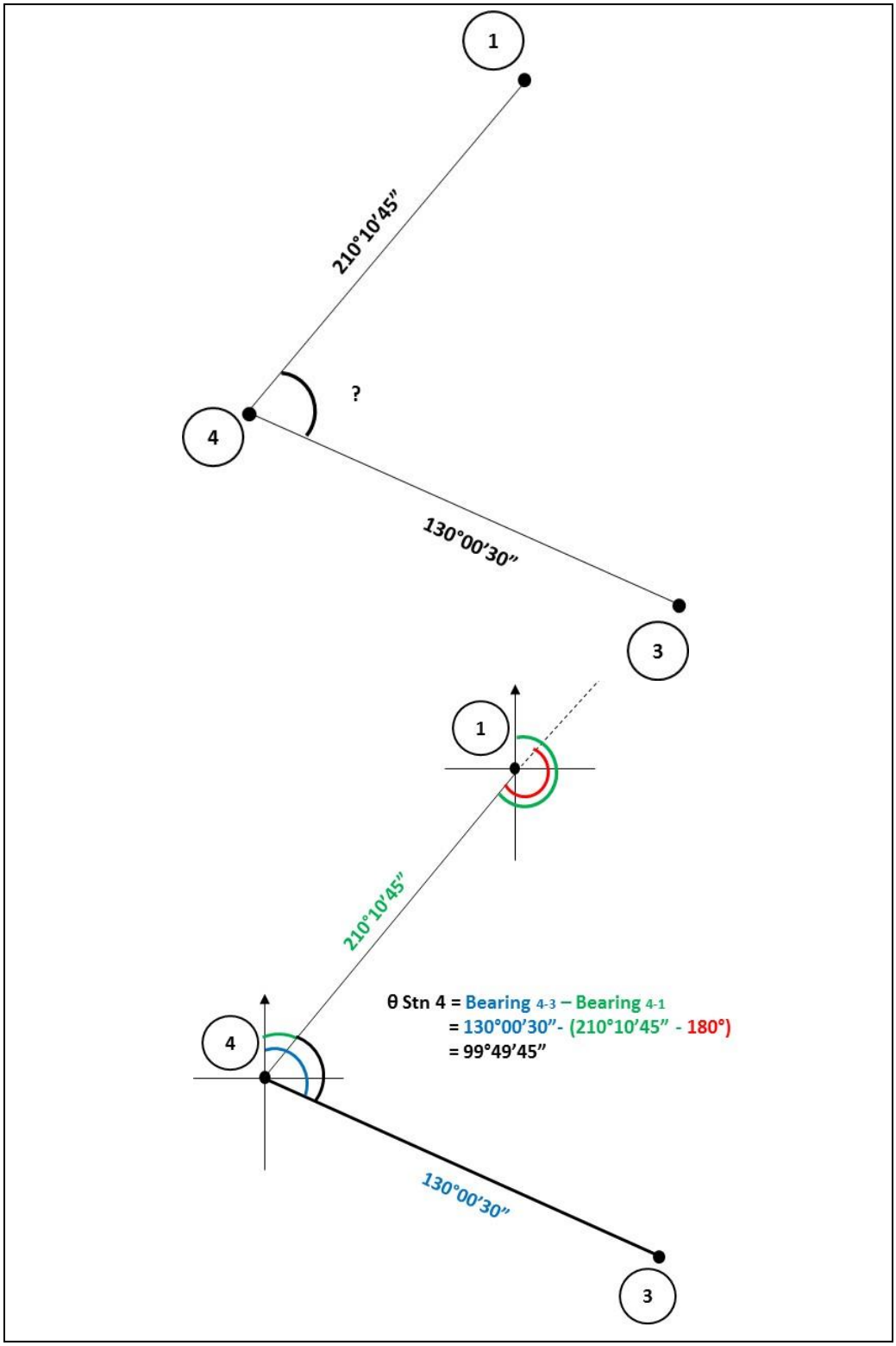


Figure 1.6

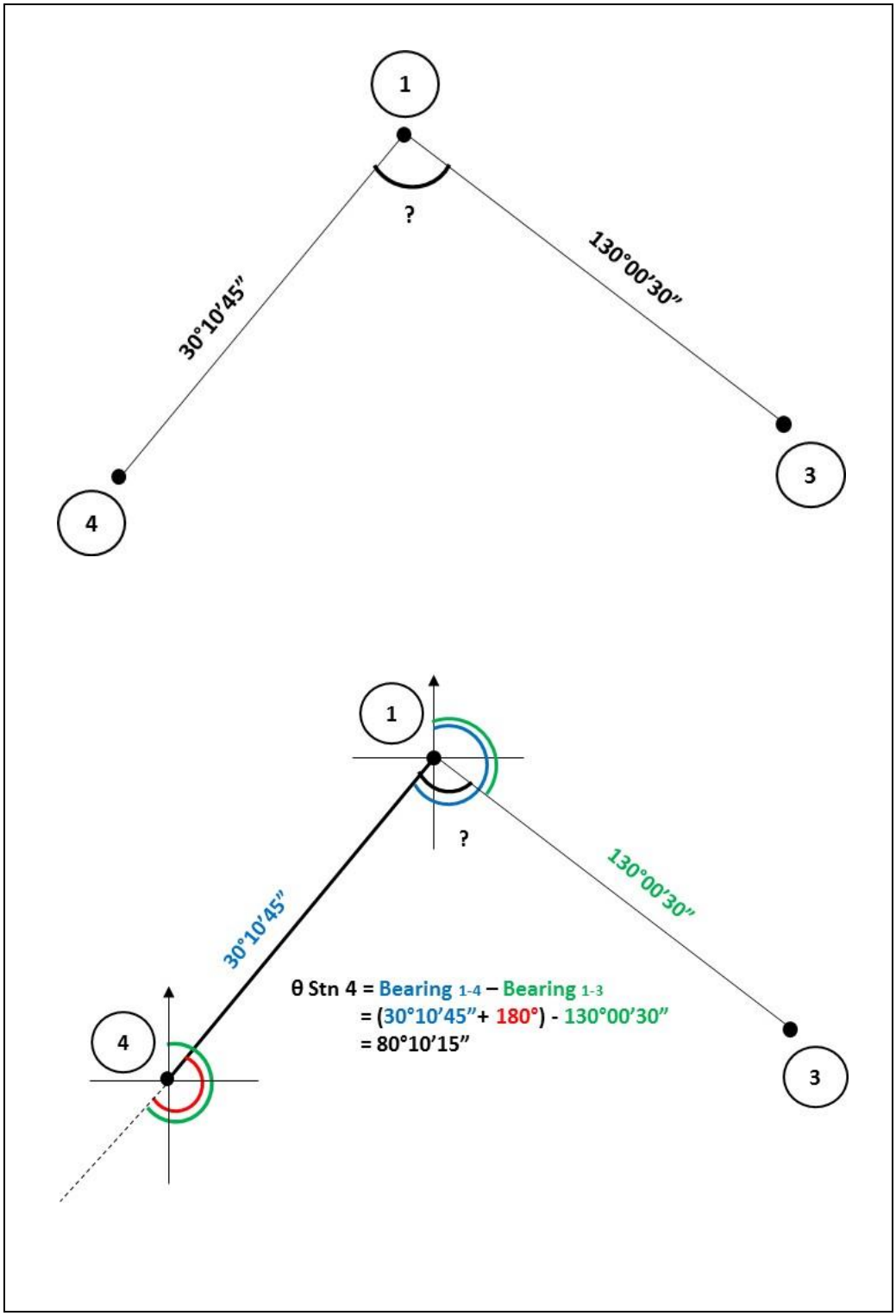

1
?
30°10'45"
130°00'30"
4
3
1
?
30°10'45"
130°00'30"
θ Stn 4 = Bearing 1-4 – Bearing 1-3
= (30°10'45"+ 180°) - 130°00'30"
= 80°10'15"
4
3

Figure 1.7

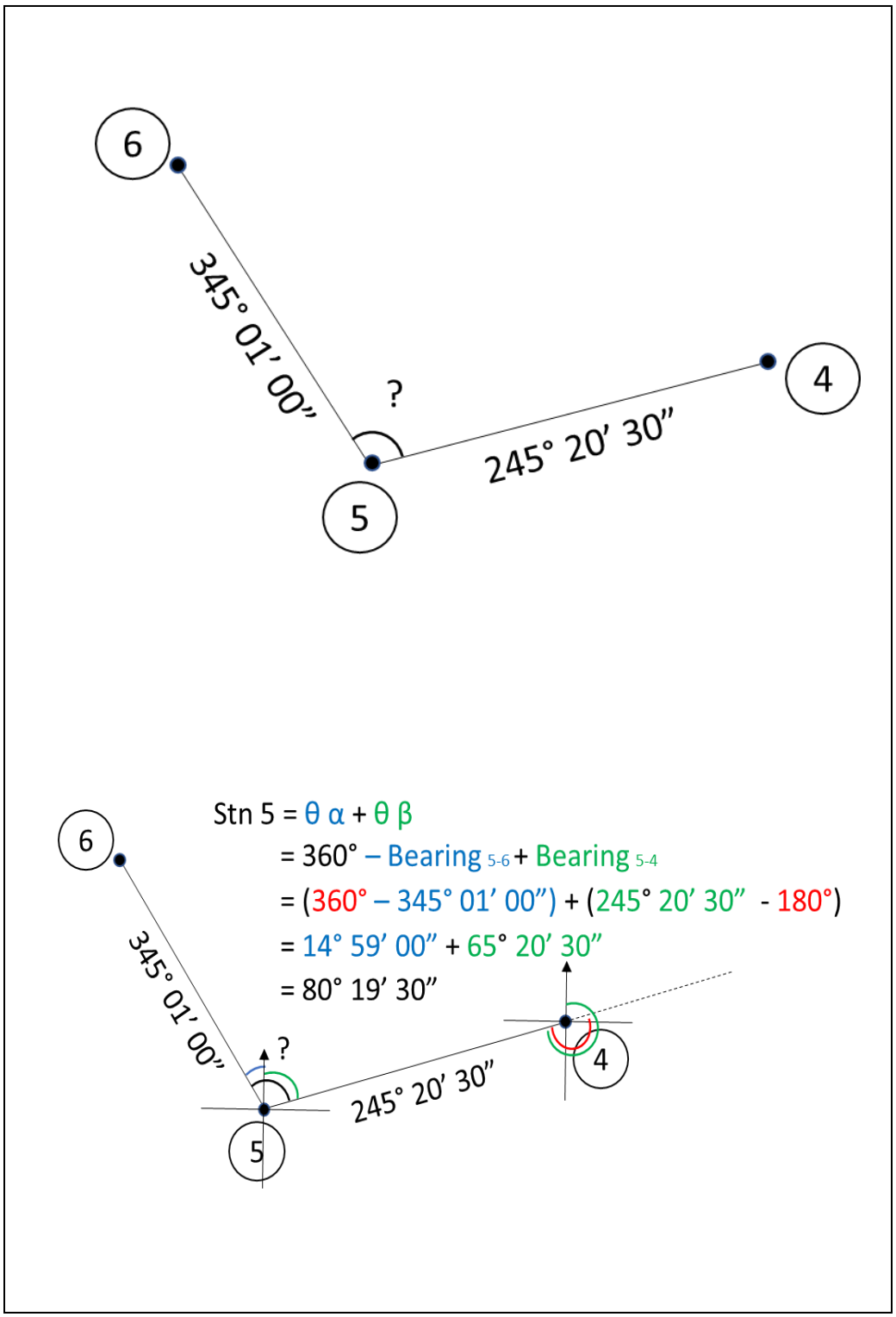

6
345° 01' 00"
?
4
245° 20' 30"
5
6
Stn 5 = θ α + θ β
= 360° – Bearing 5-6 + Bearing 5-4
= (360° – 345° 01' 00") + (245° 20' 30" - 180°)
= 14° 59' 00" + 65° 20' 30"
= 80° 19' 30"
345° 01' 00"
?
245° 20' 30"
4
5

Figure 1.8

1.1.5 Calculate the bearing from internal angle and a known bearing

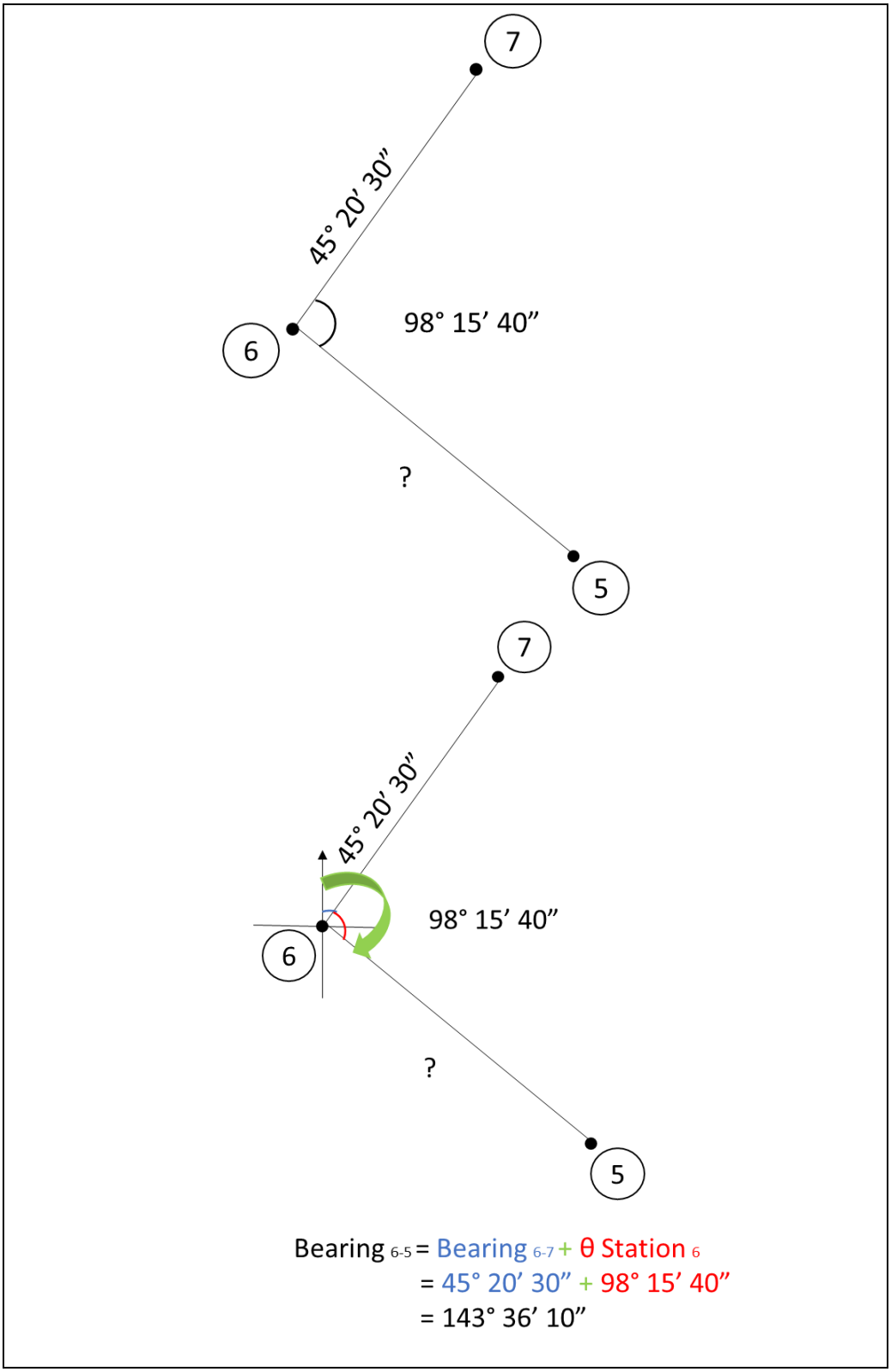
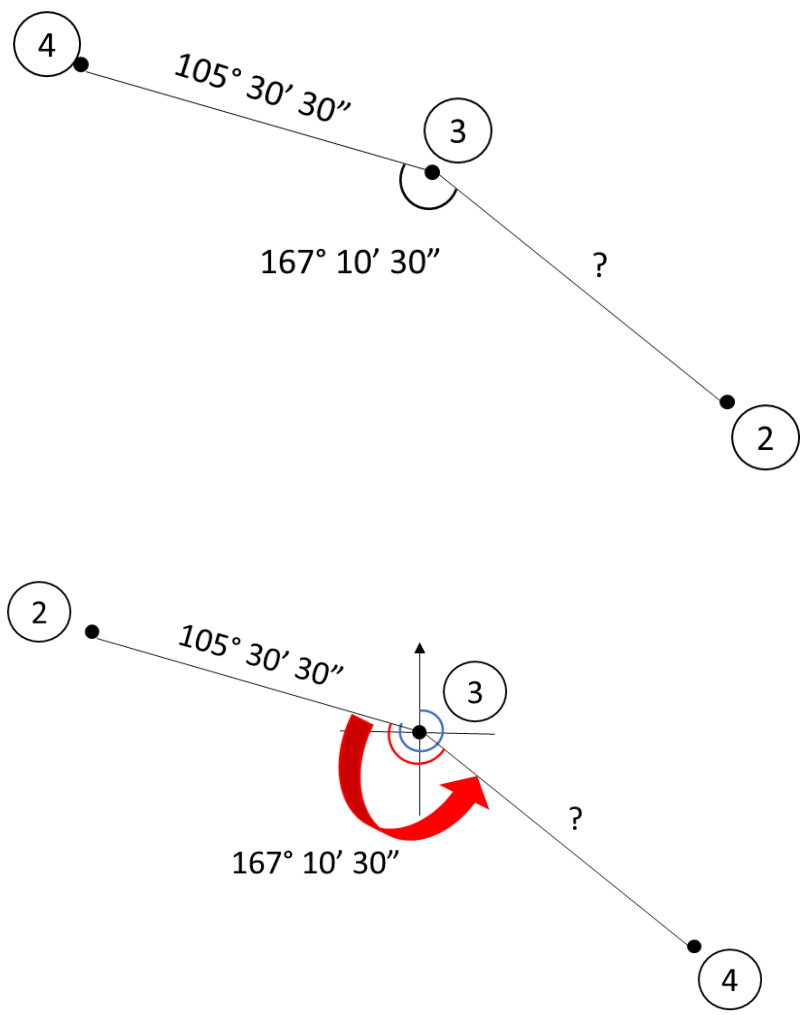


Figure 1.9

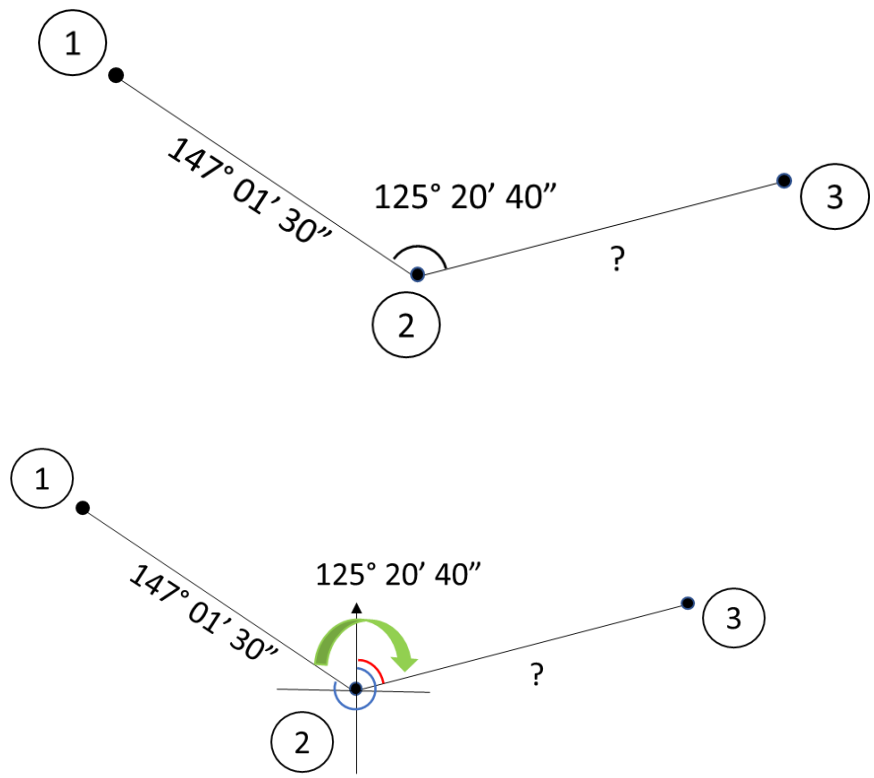


Bearing $_{3\text{-}4}$ = Bearing $_{3\text{-}2}$ - θ Station $_{3}$

= (105° 30′ 30″ + 180°) - 167° 10′ 30″

= 118° 20′ 00″

Figure 1.10



Bearing $_{2\text{-}3}$ = θ Station $_{2}$ - (360° - Bearing $_{2\text{-}1)}$

= 125° 20’ 40” - (360° - (147° 01’ 30” + 180°))

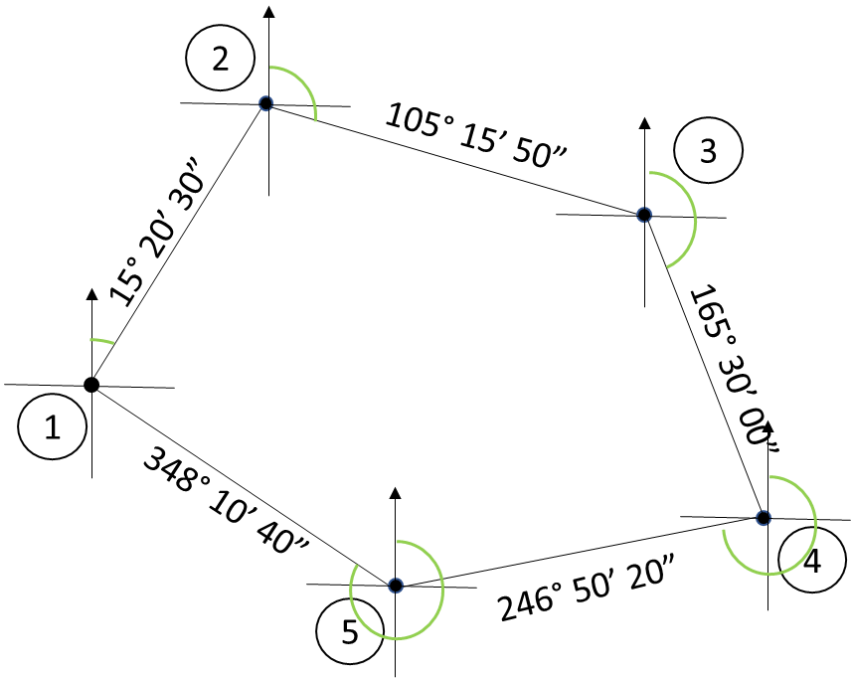
= 92° 22’ 10”

Figure 1.11

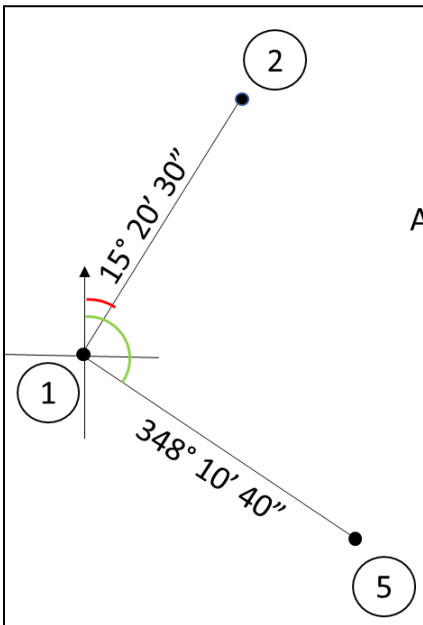
EXERCISE: SKETCH TRAVERSE & COMPUTE INTERNAL ANGLE

Survey Line	Bearing
1-2	15°20’30”
2-3	105°15’50”
3-4	165°30’00”
4-5	246°50’20”
5-1	348°10’40”

Solution for sketch traverse:



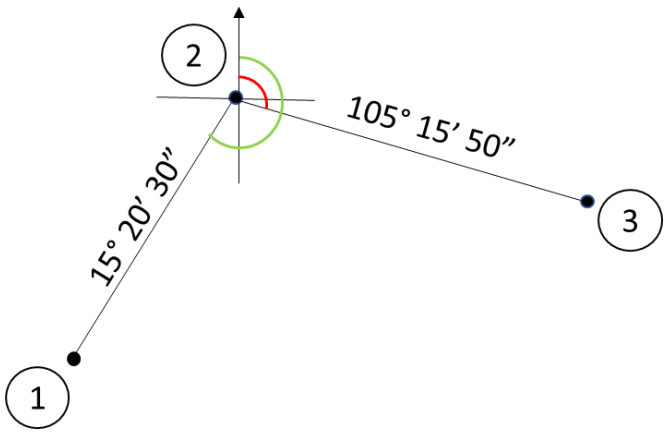
Solution for compute internal angle for traverse:



Angle $_1$= Bearing $_{1\text{-}5}$ - Bearing $_{1\text{-}2}$

= (348° 10’ 40” - 180°) - 15° 20’ 30”

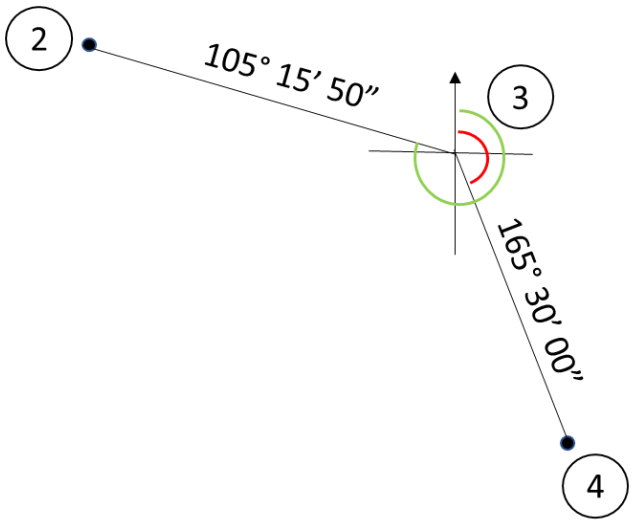
= 152° 50’ 10”



Angle $_2$ = Bearing $_{2\text{-}1}$ - Bearing $_{2\text{-}3}$

= (15° 20’ 30” + 180°) - 105° 15’ 50”

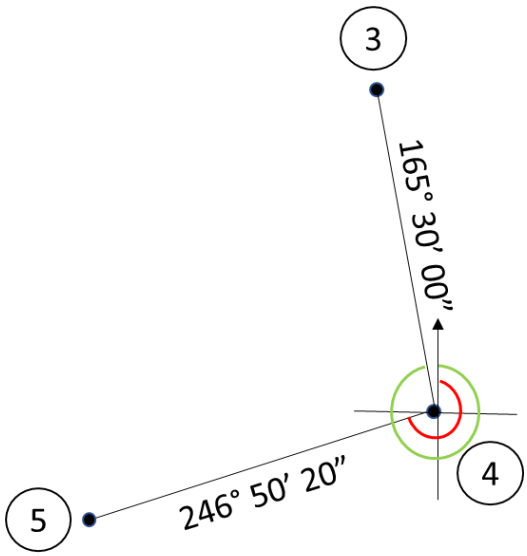
= 90° 04’ 40”



Angle $_3$ = Bearing $_{3\text{-}2}$ - Bearing $_{3\text{-}4}$

= (105° 15′ 50″ + 180°) - 165° 30′ 00″

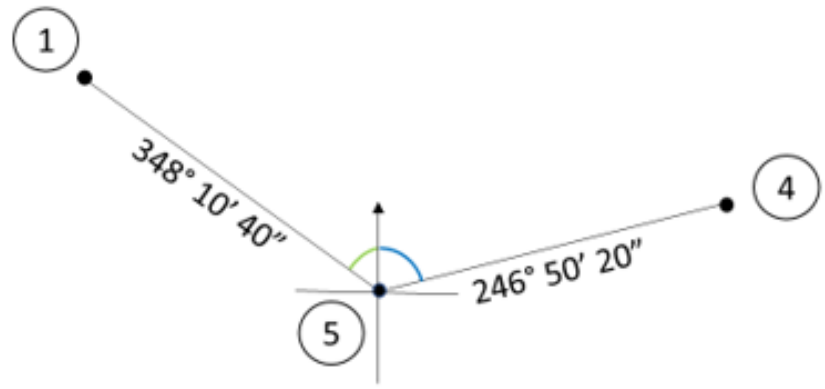
= 119° 45′ 50″



Angle $_4$ = Bearing $_{4\text{-}3}$ - Bearing $_{4\text{-}5}$

= (165° 30′ 00″ + 180°) – 246° 50′ 20″

= 98° 39′ 40″



Angle $_5$ = (360° - Bearing $_{5\text{-}1}$) + Bearing $_{5\text{-}4}$

= (360° - 348° 10′ 40″) + (246° 50′ 20″ - 180°)

= 78° 39′ 40″

TOPIC 2:

Trigonometry

2.1. Apply the concept of trigonometric function in survey problems

2.1.1 Solve the triangle problems using sine and cosine formula for triangle

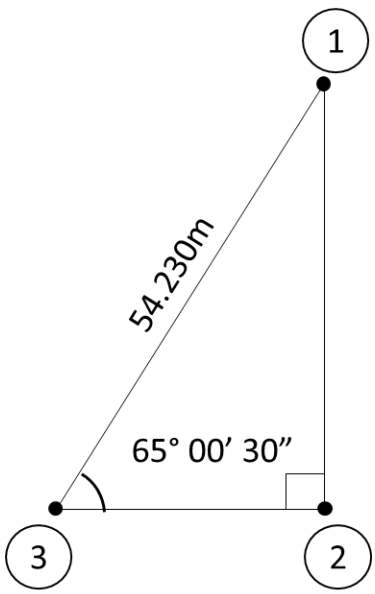
2.1.1 Solve the triangle problems using sine and cosine formula for Triangle

Trigonometry is performed by 3 angles and 3 length. Trigonometry is for survey height or distance. So must have an angle to compute.

There are two types of triangle to solve triangle in surveying. There are:

a. Right angled triangle
b. Non-right angled triangle

Right angled triangle



$$\cos\theta = \frac{\text{Station } 2-3}{\text{Station } 1-3}$$

$$\sin\theta = \frac{\text{Station } 1-2}{\text{Station } 1-3}$$

$$\tan\theta = \frac{\text{Station } 1-2}{\text{Station } 2-3}$$

Distance 1-3,

$$Station\ (1-3)^2 = (1-2)^2 + (2-3)^2$$

Distance 1-2,

$$\sin\theta = \frac{\text{Station } 1-2}{\text{Station } 1-3}$$

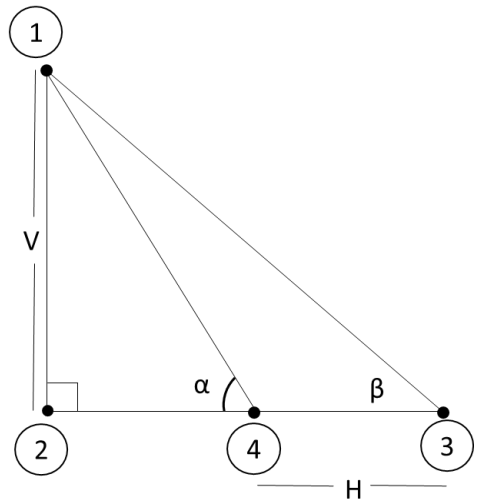
$$\sin 65°\ 00'30" = \frac{\text{Station } 1-2}{54.230}$$

$$Station\ 1-2 = \ 49.152\text{m}$$

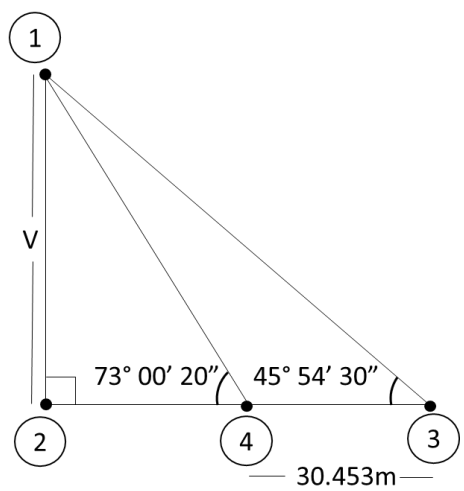
Distance 2-3,

$$Station\ (2-3)^2 = (1-3)^2 - (1-2)^2$$
$$Station\ (2-3)^2 = (54.230)^2 - (49.152)^2$$
$$Station\ 2-3 = 22.912m$$

Right angled triangle: Compute height



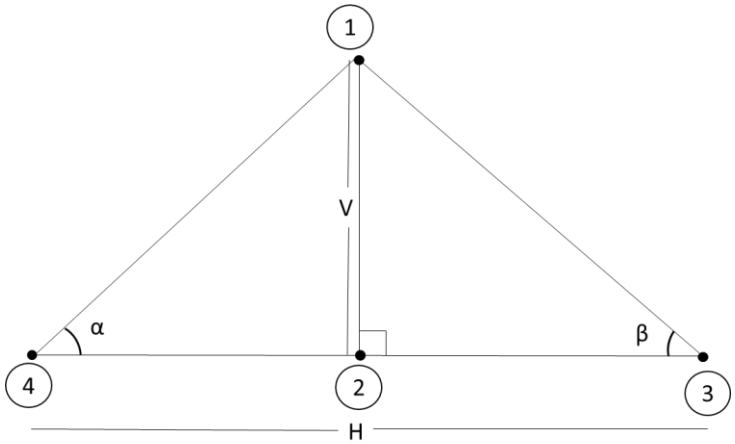
$$V = \frac{\mathrm{H}}{\cot\alpha \ - \cot\beta}$$



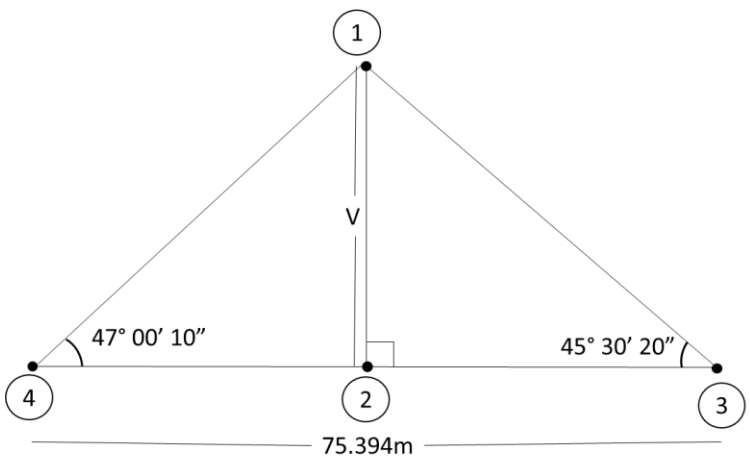
$$V = \frac{30.453}{\cot 73°\ 00'20" \ \ - \cot 45°\ 54'30"}$$

$$V = \frac{30.453}{1/\tan 73°\ 00'20 \ \text{ - } 1/\tan 45°\ 54'30}$$

$$V = 45.921m$$



$$V = \frac{\mathrm{H}}{\cot\alpha + \cot\beta}$$



$$V = \frac{\mathrm{H}}{\cot\alpha + \cot\beta}$$

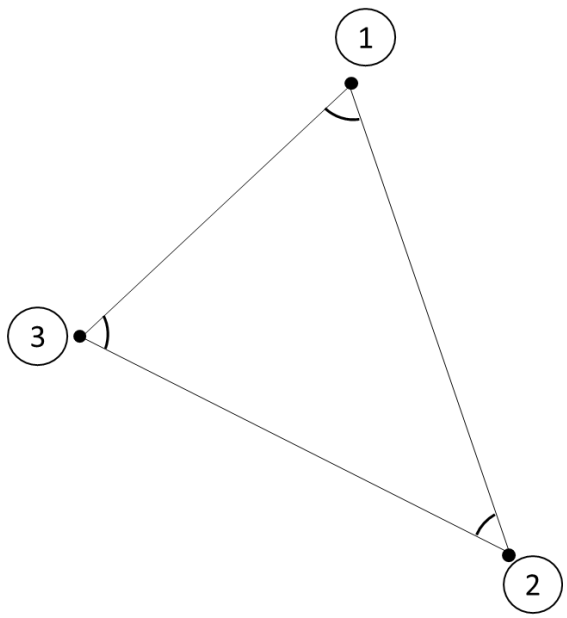
$$V = \frac{75.394}{\frac{1}{\tan} 47°\ 00'10"\ + \frac{1}{\tan} 45°\ 30'20"}$$

$$V = 39.372m$$

Non-right angled triangle

Sine Formula:

- Not right-angled triangle
- Has 2 angle & 1 distance or,
- 2 distance dan 1 angle

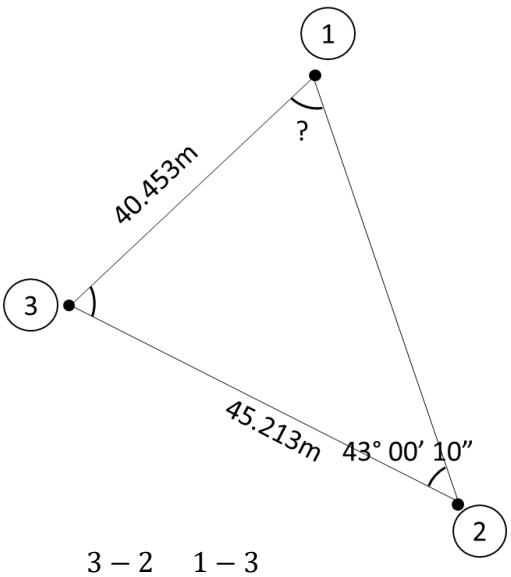


Formula

$$\frac{1-2}{\sin 3} = \frac{2-3}{\sin 1} = \frac{3-1}{\sin 2}$$

$$\frac{\sin 3}{1-2} = \frac{\sin 1}{2-3} = \frac{\sin 2}{3-1}$$

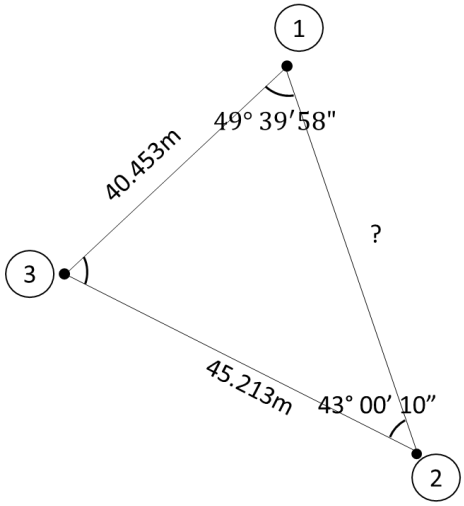
Example:



$$\frac{3-2}{\sin 1} = \frac{1-3}{\sin 2}$$

$$\frac{45.213}{\sin 1} = \frac{40.453}{\sin 43° \, 00'10''}$$

$$\theta \; 1 = 49° \, 39'58''$$



$$\theta \; 3 = 180° - (\theta \; 1 + \theta \; 2)$$

$$\theta \; 3 = 180° - (49° \, 39'58'' + 43° \, 00'10'')$$

$$\theta \; 3 = 87° \, 19' \, 52''$$

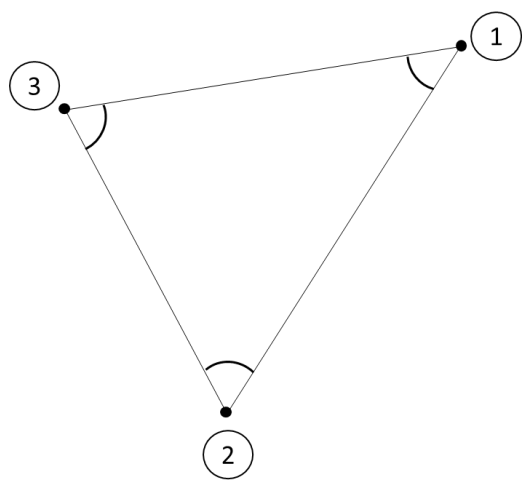
$$\frac{1-2}{\sin 3} = \frac{1-3}{\sin 2}$$

$$\frac{1-2}{\sin 87°\ 19'52''} = \frac{40.453}{\sin 43°\ 00'10''}$$

$1 - 2 = 59.248m$

Cosine Formula:

- Not right-angled triangle
- Has 2 distance & 1 angle or,
- 3 distance given



Formula

$(1-2)^2 = (1-3)^2 + (2-3)^2 - 2(1-3)(2-3)\ cos\ 3$

$(2-3)^2 = (1-3)^2 + (1-2)^2 - 2(1-3)(1-2)\ cos\ 1$

$(3-1)^2 = (1-2)^2 + (2-3)^2 - 2(1-2)(2-3)\ cos\ 2$

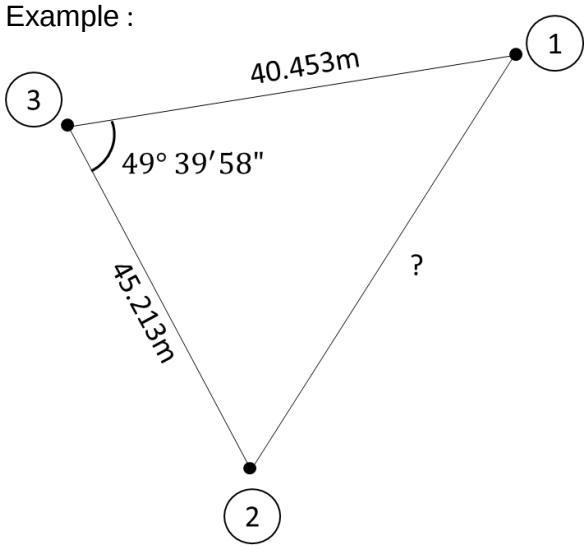
or

$$\cos 1 = \frac{(1-3\ )^2 + (1-2)^2 - (2-3)^2}{2\ (1-3)(1-2)}$$

$$\cos 2 = \frac{(2-3\ )^2 + (2-1)^2 - (1-3)^2}{2\ (2-3)(2-1)}$$

$$\cos 3 = \frac{(3-1\ )^2 + (3-2)^2 - (1-2)^2}{2\ (3-1)(3-2)}$$

Example :



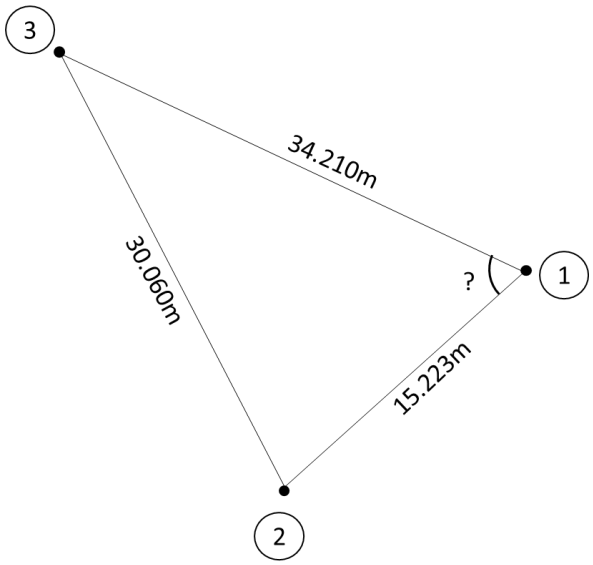
Based on data given, cannot use sin formula because opposite to angle 3 is no distance, so by data given must use cosine formula.

$$(1-2)^2 = (1-3)^2 + (2-3)^2 - 2(1-3)(2-3)\ cos\ 3$$

$$(1-2)^2 = (40.453)^2 + (45.213)^2 - 2(40.453)(45.213)\ cos\ 49°\ 39'58"$$

$$(1-2)^2 = 1313.051936$$

$$1-2 = 36.236m$$

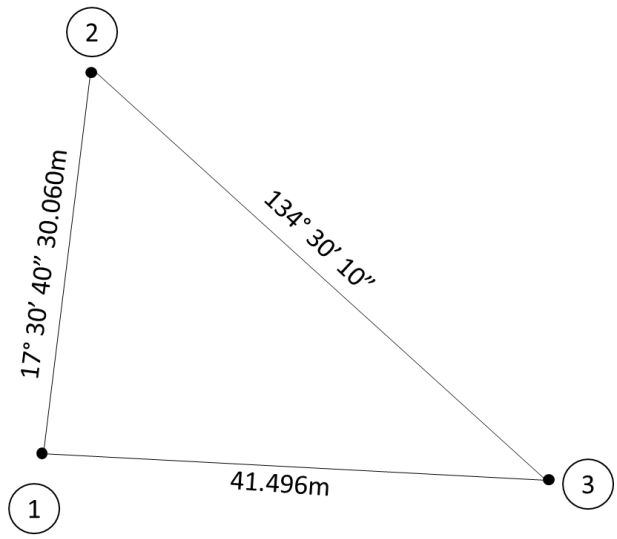


$$\cos 1 = \frac{(1-3\ )^2 + (1-2)^2 - (2-3)^2}{2\ (1-3)(1-2)}$$

$$\cos 1 = \frac{(34.210)^2 + (15.223)^2 - (30.060)^2}{2\,(34.210)(15.223)}$$

$\theta 1 = 61°\ 24'\ 28"$

Sometimes, formula sine and cosine must be combined to get the data. Example, compute the bearing of survey line 3-1 and distance 2-3.



Angle Station 2,
$= bearing\ Station\ 2 - 1 - bearing\ Station\ 2 - 3\ 43°\ 00'10"$
$= (17°\ 30'40"\ +\ 180°)\ -\ 134°\ 30'10"$
$= 63°\ 00'30"$

$$\frac{1-3}{\sin 2} = \frac{1-2}{\sin 3}$$

$$\frac{41.496}{\sin 63°\ 00'30"} = \frac{30.060}{\sin 3}$$

$41.496\ x \sin 3 = 30.060\ x \sin 63°\ 00'30"$

$$\sin 3 = \frac{30.060\ x \sin 63°\ 00'30"}{41.496}$$

$\theta 3 = 40°\ 12'\ 11"$
Angle Station 1,
$= 180° - (Angle\ Station\ 2 +\ Angle\ Station\ 3)$
$= 180° -\ (63°\ 00'30" + 40°\ 12'\ 11")$
$\theta 1 = 76°\ 47'19"$

Bearing 3-1,

$= (Bearing\ 3 - 2) - Angle\ 3$

$= (134° \ 30' 10" + 180°) \ - 40° \ 12' \ 11"$

$= 274° \ 17' 59"$

Distance station 2-3,

$(2 - 3)^2 = (1 - 3)^2 + (1 - 2)^2 - 2(1 - 3)(1 - 2) \ cos \ 1$

$(2 - 3)^2 = (41.496)^2 + (30.060)^2 - 2(41.496)(30.060) \ cos \ 76° \ 47' 19"$

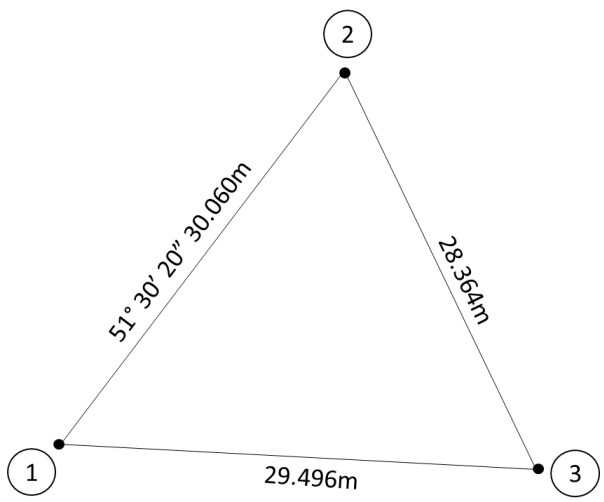
$(2 - 3)^2 = 2055.363$

$2 - 3 = \sqrt{2055.363}$

$2 - 3 = 45.336m$

Half Angle Triangle Formula:

- Not right-angled triangle
- 3 distance given



Compute Bearing 2 to 3.

$$\frac{\sin\theta 2}{2} = \sqrt{\frac{(\mathrm{s} - \mathrm{S1S2})(\mathrm{s} - \mathrm{S2S3})}{S1S2\ x\ S2S3}}$$

$$\text{where, s} = \frac{S1S2 + S2S3 + S3S1}{2}$$

$$\text{where, s} = \frac{30.060 + 28.364 + 29.496}{2}$$

$$s = 43.960m$$

$$\frac{\sin\theta 2}{2} = \sqrt{\frac{(43.960 - 30.060)(43.960 - 28.364)}{30.060\ x\ 28.364}}$$

$$\frac{\theta 2}{2} = 30°\ 16'\ 51"$$

$$\theta 2 = 60°\ 33'\ 42"$$

Bearing 2-3,

$$= (Bearing\ 2 - 1) - Angle\ 2$$

$$= (51°\ 30'20" + 180°)\ - 60°\ 33'\ 42"$$

$$= 170°\ 56'38"$$

Tangent Napier's Formula:

- Not right-angled triangle
- 2 distance & 1 angle given

This formula suitable if compute 2 angle at once.

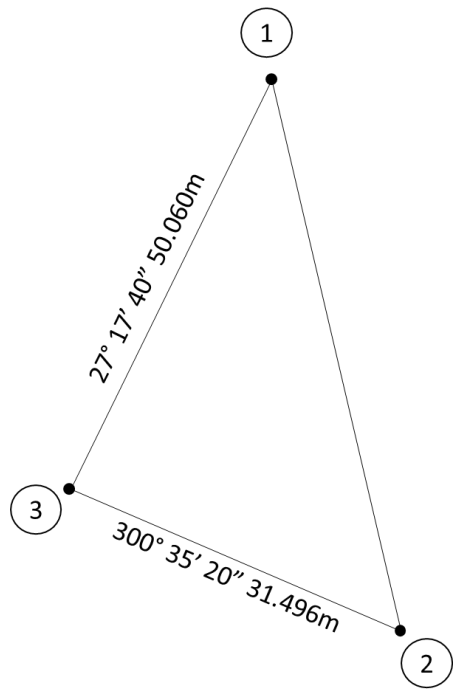
Compute angle station 1 and 2.

Angle Station 3,

$= (Bearing\ 3-2) - (Bearing\ 3-1)$

$= (300°\ 35'\ 20"\ -\ 180°)$ - $27°\ 17'\ 40")$

$\theta 3 = 93°\ 17'40"$



$$tan\frac{\theta 1-\ \theta 2}{2} = \frac{S3S1 - S3S2}{S3S1 + S3S2)}\tan\frac{\theta 1+\ \theta 2}{2}$$

$\theta 1+\ \theta 2\ = 180° - 93°\ 17'40"$

$\theta 1+\ \theta 2\ = 86°\ 42'20"$ ……..equation 1

$$tan\frac{\theta 1-\ \theta 2}{2} = \frac{50.060 - 31.496}{50.060 + 31.496}\tan\frac{86°\ 42'20"}{2}$$

$$tan\frac{\theta 1-\ \theta 2}{2} = \frac{18.564}{81.556}\tan 43°\ 21'10"$$

$$tan\frac{\theta 1-\ \theta 2}{2} = 0.214897031$$

$$\frac{\theta 1-\ \theta 2}{2} = 12°\ 07'42"$$

$\theta 1-\ \theta 2 = 24°\ 15'23"$ ……..equation 2

But

$\left.\begin{array}{l}\theta 1+\ \theta 2\ = 86°\ 42'20" \\ \theta 1-\ \theta 2 = 24°\ 15'23"\end{array}\right\}$ -

$2(\theta 2) = 62°\ 26'57"$

$\theta 2 = 31°\ 13'29"$

So,input $\theta 2 = 31°\ 13'29"$ in equation 1, $\theta 1+\ \theta 2\ = 86°\ 42'20"$

$\theta 1+\ \theta 2\ = 86°\ 42'20"$

$\theta 1+\ 31°\ 13'29"\ = 86°\ 42'20"$

$\theta 1 = 86°\ 42'20"\ -\ 31°\ 13'29"$

$\theta 1 = 55°\ 28'51"$

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