Angles Between Intersecting Lines

(The 'Construct Intersection' Command)

Introduction

The 'Construct Intersection' command in Basic-X and Gage-X has the ability to give angular results of two intersecting lines. This document is designed to give an explanation of the ideology and parameters that affect how the resultant angles are defined and reported.

Angles Defined

- Angle 1 is the included angle.
- Angle 2 is the resultant of Angle 1 or 360º - Angle 1.
- Angle 3 is 180º - Angle 1 (if this is negative, it is added to 360º).
- Angle 4 is the resultant of Angle 3 or 360º - Angle 3.

Example

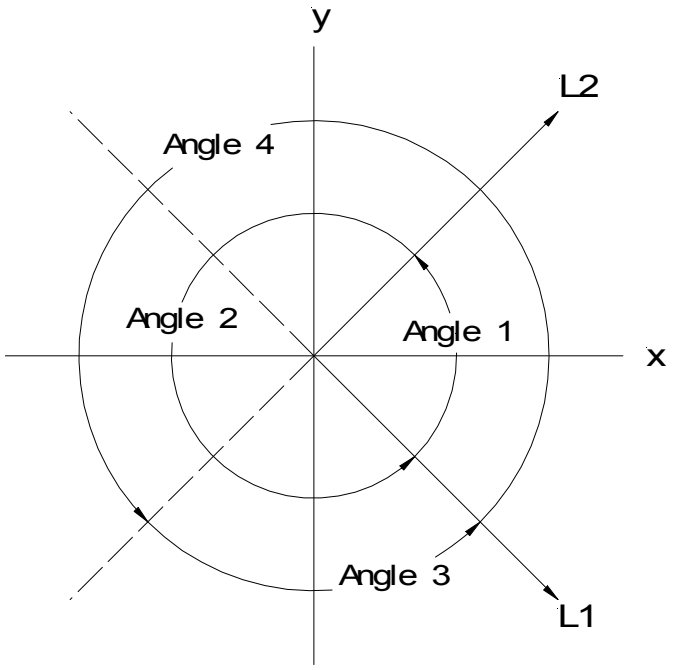

Fig. 1

-All angles are reported in a positive (counter-clockwise) direction from the first line to the second line.
-The order in which the angles are displayed depends on which line was selected (not measured) first.

Vectors Defined

The included angle is calculated from the endpoint of the first line to the endpoint of the second line. The endpoint is determined by the vector direction in which the line was measured.

- For constructed lines or lines measured from individual points, the vector direction is determined by the first two points measured or selected.

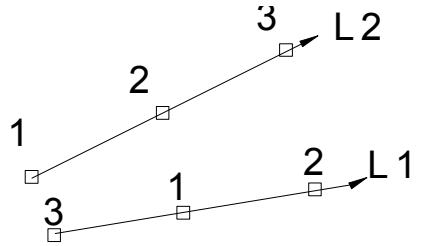

Fig. 2
Vector direction determined by the first two points (points 1 & 2 in example) measured or selected.

- For lines measured with the feature finder or edge trace tools, the vector direction of the line is based on the "Light-on-the-right" rule. For example, points are measured clockwise for a rectangular through hole and counter-clockwise for a solid object or outer edge.

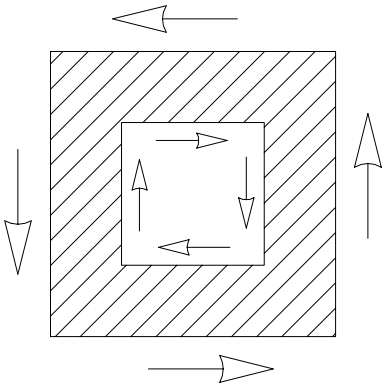

Fig. 3
Light-on-the-right

Two Factors That Determine Included Angle

There are two major factors that determine the included angle of two intersecting lines: The vector direction of the lines and the order the lines are selected.

The following example will illustrate an ideal situation.

- The lines are created using points in an order that creates line vectors directed away from the intersection point.
- The lines are selected in a CCW direction.

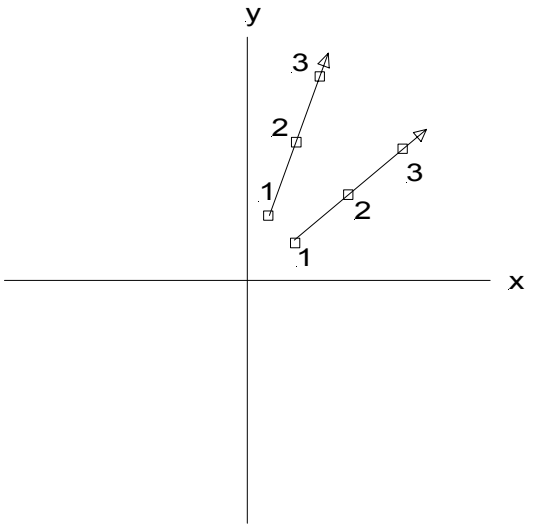

Fig. 4
Vector direction as a result of creation points.

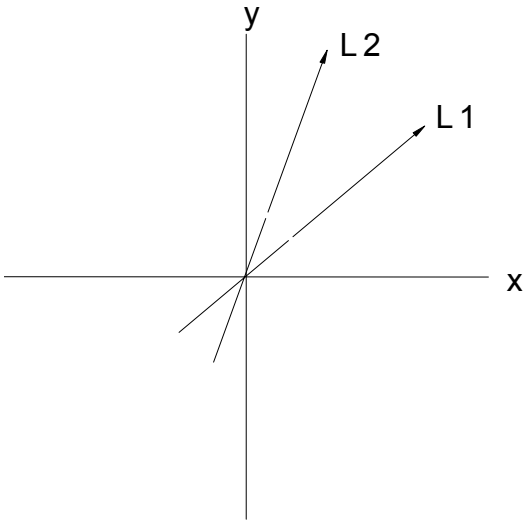

Fig. 5
Lines are selected in CCW direction. (L1 selected 1st, L2 selected 2nd)

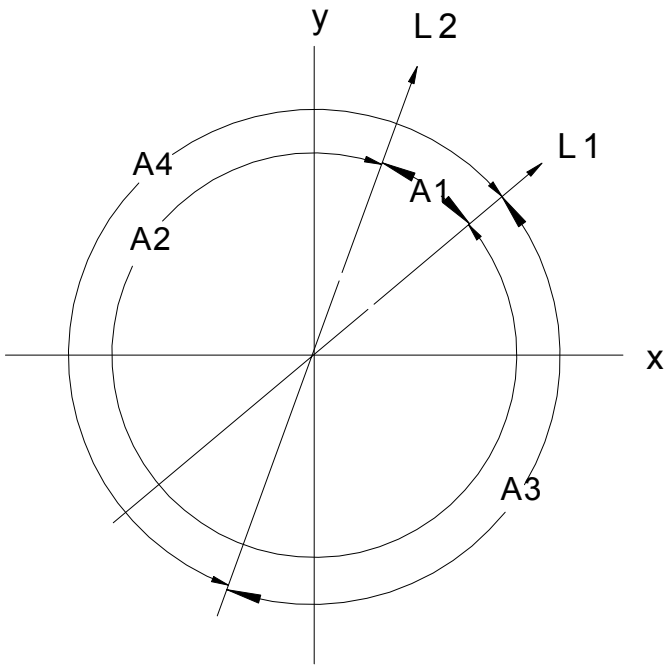

Fig. 6

Angle designation as a result of vector direction and line selection.

Adding real numbers to our example:
-Angle 1 is 30º.
-Angle 2 = 360º -30º = 330º.
-Angle 3 =180º - 30º (Angle 1) = 150º.
-Angle 4 = 360º - 150º (Angle 3) = 210º.

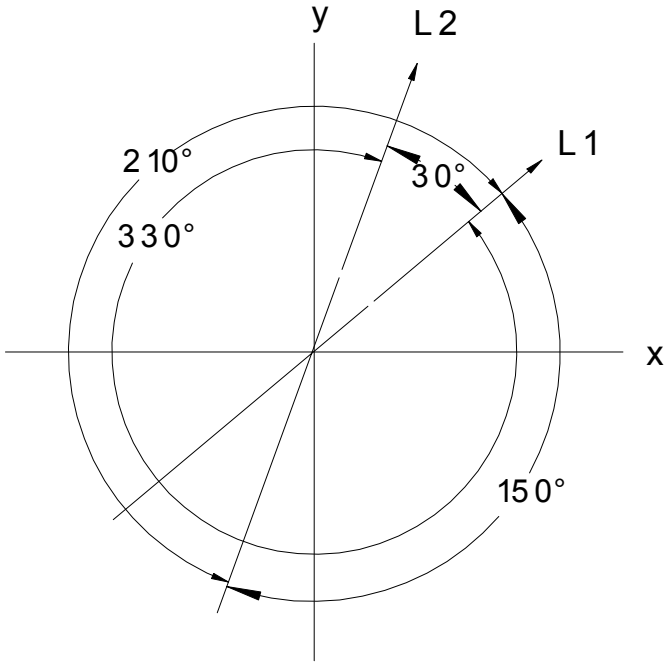

Fig. 7

We will now repeat the previous example with the exception of how the lines are measured. In this example, the lines are measured using the feature finder tool. Because the feature finder tool uses the "Light-on-the-right" rule, our vector directions will not be the same as the previous example.

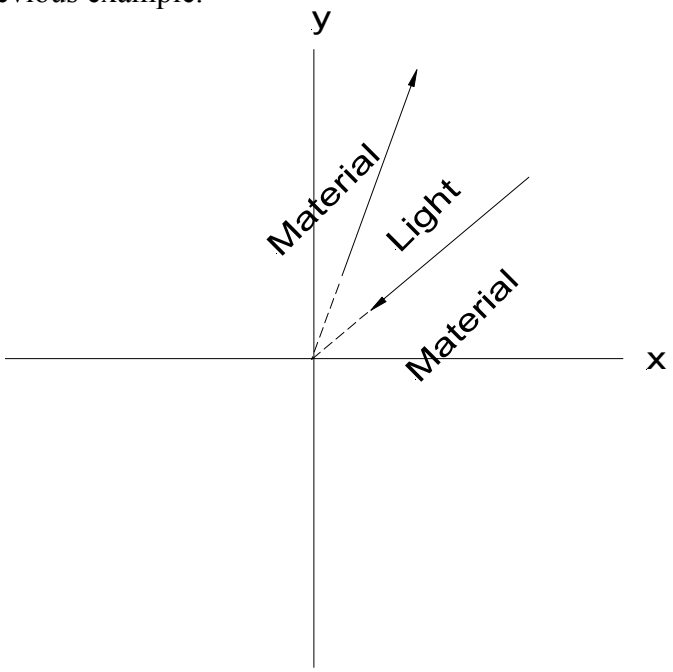

Fig. 8
Vector directions as a result of using "Light-On-The-Right" rule.

In a previous discussion, it was stated that the included angle is calculated from the endpoint of line 1 to the endpoint of line 2. The end point of a line is defined by the last point in the vector direction of the measured line.

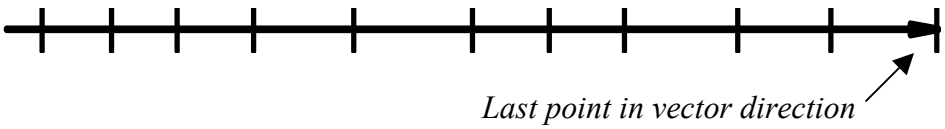

Fig. 9

In the event the resultant vector of on of the measured lines is pointing in the direction of the intersection of the two measured lines, the end point is projected to the opposite side of the intersection point. Essentially, the end point of a measured line is always calculated away from the intersection point in the direction of the vector.

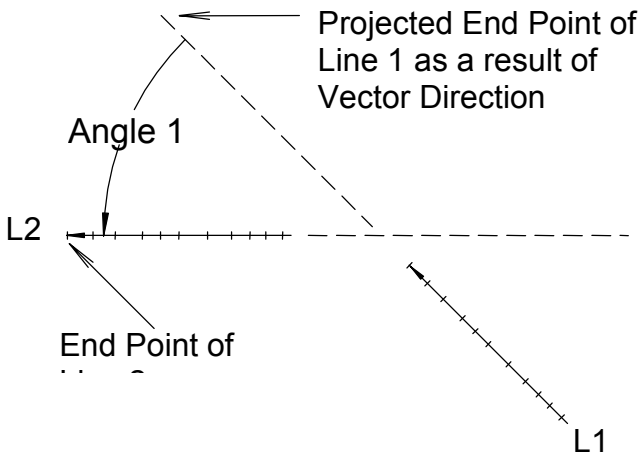

Fig. 10

Example

Taking into consideration the two factors that establish the included angle, vector direction and line selection sequence, here is an example using the Feature Finder tool to measure intersecting features.

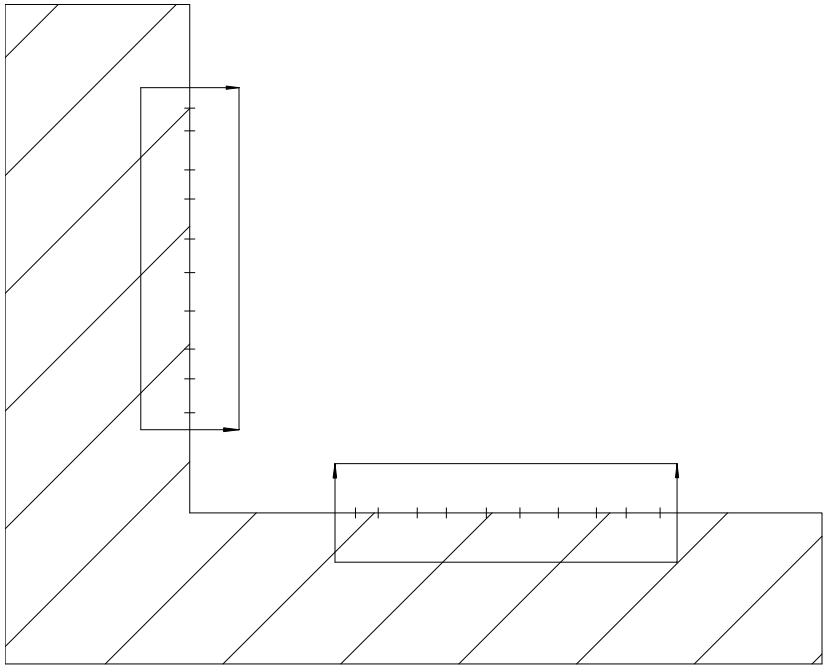

Fig. 11
Two intersecting features measured using the Feature Finder tool.

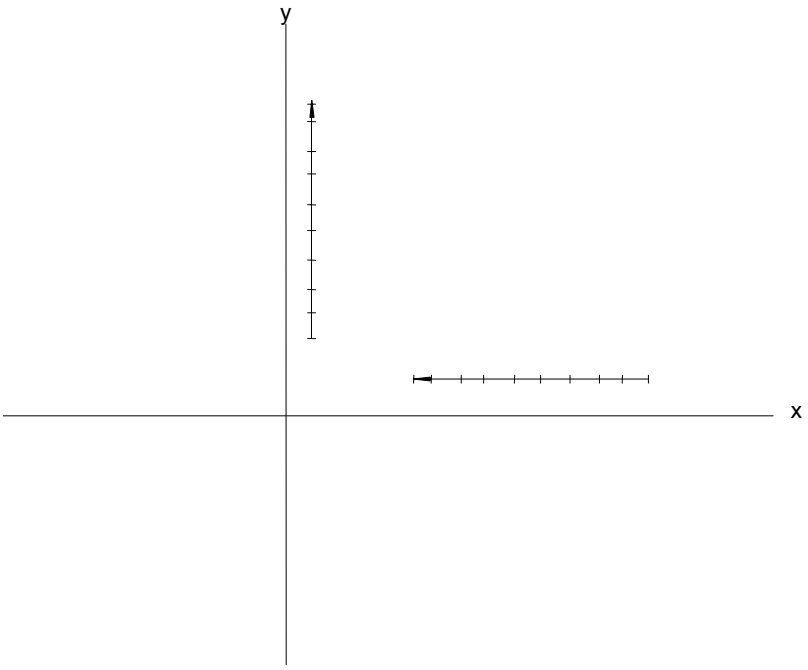

Fig. 12
Vector direction resulting from the measured lines.

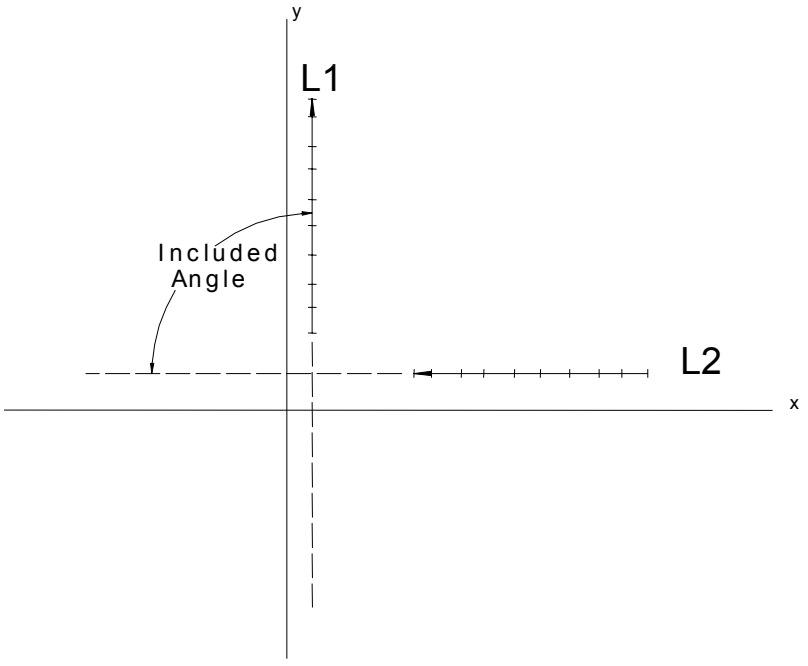

Fig. 13
The included angle result using the 'Construct Intersection' tool, then selecting line one (L1) and then line two (L2).

Exercise

This exercise is designed to walk the operator or programmer through a 'real world' example using the intersect tool. For the exercise, you may use the 'FastStart' training part that was supplied with your measurement system or you can create your own by printing this page and cutting out the graphics below.

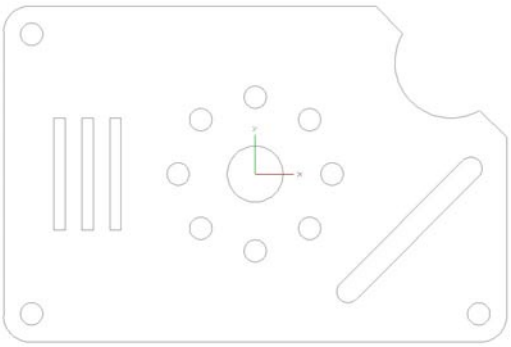

Fig. 14
FastStart training part supplied by QVI

Fig. 15
Print page and cut out graphic.

Step 1-

Using back light illumination, measure the top and angled edges of the part using the 'Feature Finder' tool.

Step 2-

Using the 'Construct Intersection' tool, select the angled line 1st and then the horizontal (top) line.

Step 3-

Before reviewing the Angle results, hand sketch what you think the layout will look like. Include the vector directions, extend the lines through the intersection point and mark the included Angle (Angle 1).

Step 4-

Now, in the Intersect window, look at the angle results for Angle 1. It should be around 45º. Look at the other angle results. Are they close to the following?
Angle 2 = 315º
Angle 3 = 135º
Angle 4 = 225º

Additional practice-

Try this exercise again except select the horizontal (top) line first. Are your results close to the following?

Angle 1 = 315º
Angle 2 = 45º
Angle 3 = 225º
Angle 4 = 135º