

CARTESIAN COORDINATE SYSTEM

For Quiz Purposes:

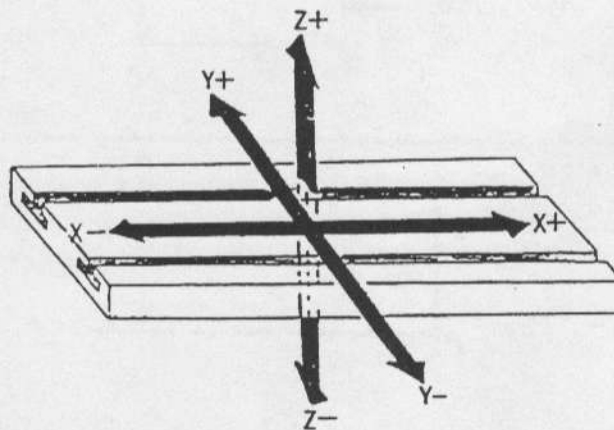
Read all information provided in this unit area.

Overview:

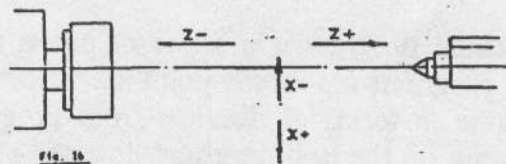
The Cartesian Coordinate system of locating points can be used in association with table movements on a mill or tool movement on a lathe.

Machine Movements - X Y Z Axis

Programmed machine tools use the axis identification system. When looking down on a milling machine table, "X-" is to the left on the table "X +" is to the right on the table. "Y -" is toward the operator on the table and "Y +" is away from the operator on the table. If the cutting tool moves down toward the table it is "Z -" and if the cutting tool moves away from the table it is "Z +". (This information must be memorized.)



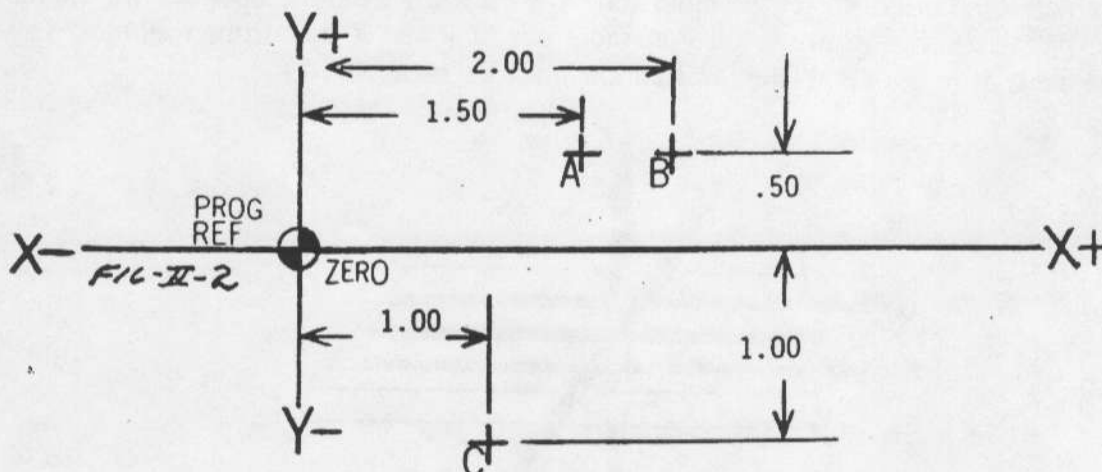
When programming a two axis CNC lathe the "Z" axis is the longitudinal feed and the cross feed is the "X" axis. A command of "X -" moves the tool away from the operator, while "X+" moves the tool toward the operator. A command of "Z +" moves the cutter toward the tailstock or the right of the operator, while "Z -" moves the tool toward the headstock or the left of the operator. (This information must be memorized.) Often, on modern CNC lathes, the X axis is tilted. This is called a "slant bed" lathe.



In CNC programming there are three ways of identifying the location of a point in a program. A point is a position on the part or machine. These are:

AbsoluteRelativePolar

The **Absolute** and **Relative** systems are similar to graph paper in that they form a grid of lines crossing at 90 degrees. (In fact it is beneficial to layout all parts to be produced on graph paper of 10 squares per inch or at least 4 squares to the inch before starting to program.) This type of point location or identification system is called **CARTESIAN COORDINATE** system. Relative and absolute values are units we use in the Cartesian system. **POLAR** units are based upon a radius and angle and will be studied later time.



Absolute Values:

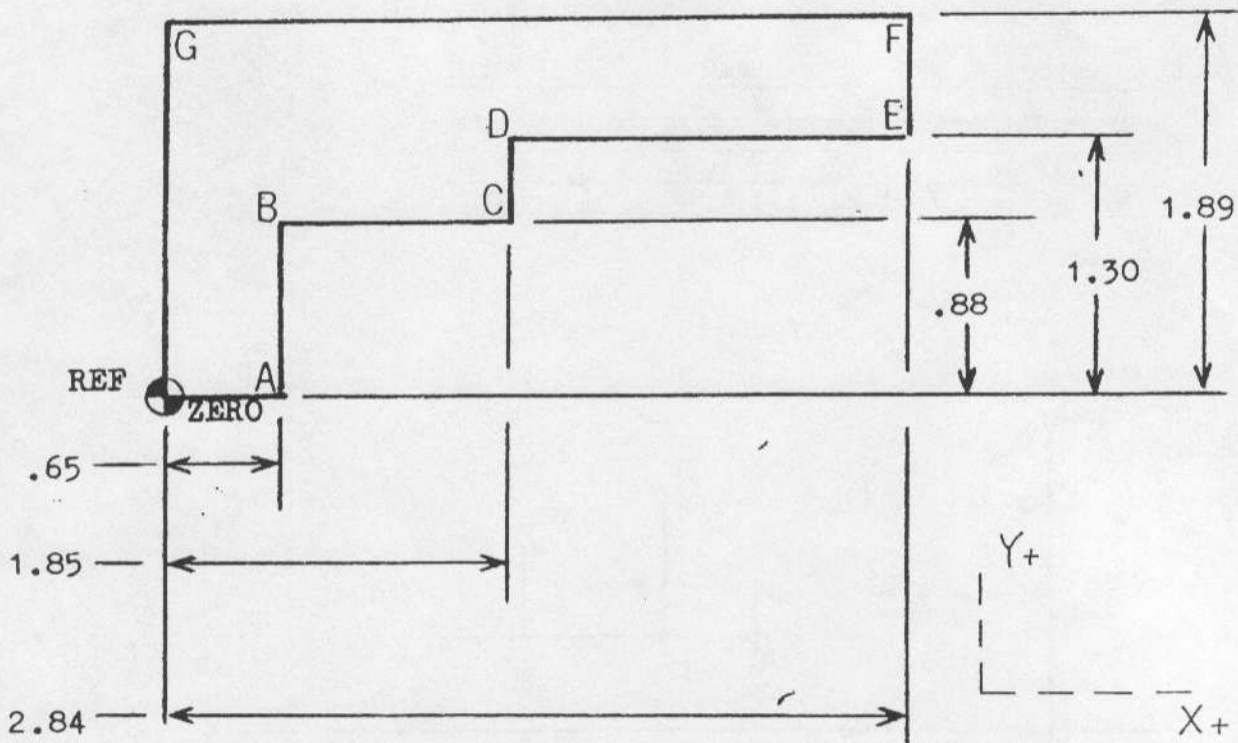
Absolute Values always relate to a base position. This base position is known as the **PROGRAM REFERENCE ZERO**. (Identified as X 0.000 and Y 0.000 and Z 0.000) All distances are related to this point. Points are identified as to how far they are from **PROGRAM REFERENCE ZERO (P.R.Z.)** In the illustration, the location of point A in relation to P.R.Z. is X 1.500 and Y .500 That is to say we must travel 1.500" in X and .500" in Y to get to point A from Program Reference Zero.

Understanding A Set of Points:

The main part of a machine program is a series of points to which we wish the machine to move. The body of programs are mostly point identification. If it is desired to identify point B, it must be done in terms of distance from Program Reference Zero. (P.R.Z.) Study the simple program on the next page and note the movement in the figure above. This program will go from PRZ to point A to B to C back to PRZ.

Sequence Number	Point Identification	Explanation
001	X 1.500 Y .500	Move from PRZ to A
002	X 2.000 Y .500	Move from A to B
003	X 1.000 Y -1.000	Move from B to C
004	X 0.000 Y 0.000	Move from C to PRZ

Remember this program uses absolute values for point identification. Each point is located in relation to the PRZ. In sequence number 3, the value for Y is negative because point C was below the Y reference line.



Write a program of Absolute Values for this drawing. Start at P.R.Z.

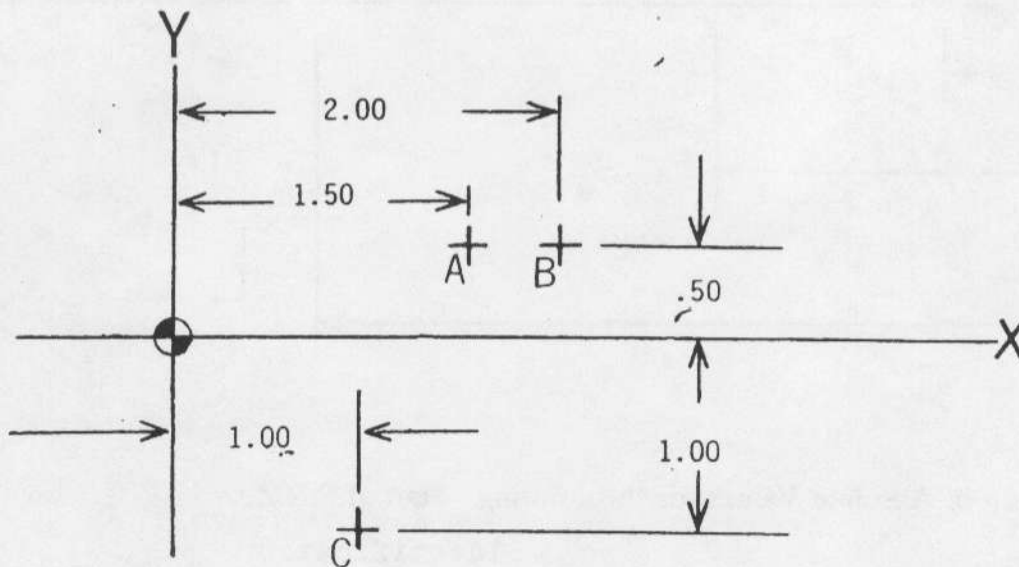
Sequence	Identification Points
001	A
002	B
003	C
004	D
005	E
006	F
007	G

Relative Values:

The second point identification system is the **RELATIVE** system. In the Relative system, the distances are not compared to program reference zero; they are compared to the last position. Each new movement is related only how far you wish to go from the last position. This system is also called the **INCREMENTAL** system.

The following program is a RELATIVE value program for these points. Study the program then compare it to the absolute value program for the same point. The program goes from P.R.Z. to point A, B, C, and back to PRZ.

SEQUENCE	PROGRAM		POINT
1	X 1.50	Y .50	A
2	X .50	Y 0.00	B
3	X -1.00	Y-1.50	C
4	X -1.00	Y 1.00	PRZ



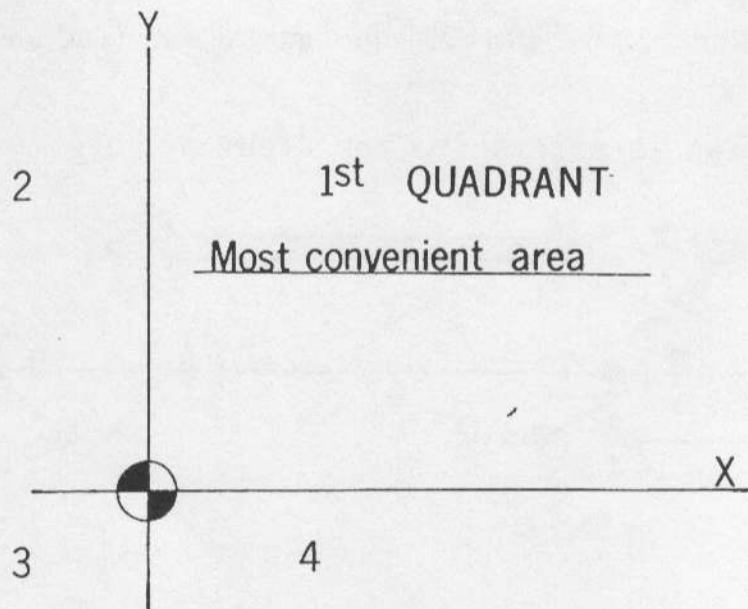
Notice in this system the movements to the right in X, away from the operator in Y and up in Z are positive. Movements to the left, toward the operator and down are negative.

* Note Y axis movement was not needed at point "B" so Y=0.000 was the entry; however, on many CNC controllers, the Y entry would simply not be given and the computer would understand that Y was not to move. Either is acceptable.

The Quadrants:

If the X-Y plane is divided into four parts starting from the zero point, each fourth is called a quadrant. The quadrants are numbered in a counter-clockwise direction starting at the 3 o'clock position. If PRZ is at the center of the quadrants then all programmed moves should be made to the right and up - this is the first quadrant.

Any place may be chosen for the PRZ; however, the lower left corner of the part is ideal because all of the points in absolute will be positive. If the PRZ is the farthest left in the X axis and farthest toward the operator in the Y axis, then all moves will stay in the first quadrant.



Try to machine in the first quadrant by choosing the PRZ at the far left, lower corner. This is the most minus X and minus Y point on the part. The PRZ need not be located on the actual part. Often it is more convenient to choose a PRZ that is on a fixture or tooling so multiple parts can be machined. This tooling point is usually a hole that is easily located by the machine operator. This point would also be chosen so that all program moves will be positive using absolute values. While this does not effect relative values, we still choose the PRZ to the lower left for consistency.

Absolute Values Compared to Relative Values:

Both systems have usefulness. Both systems have advantages and disadvantages. It is the drawing that will dictate which value system unit should used to write the program. Often the most efficient way to program is with a mixture. By choosing the point identifications well, a good programmer may save much needless math and chance for errors.

Relative Values:

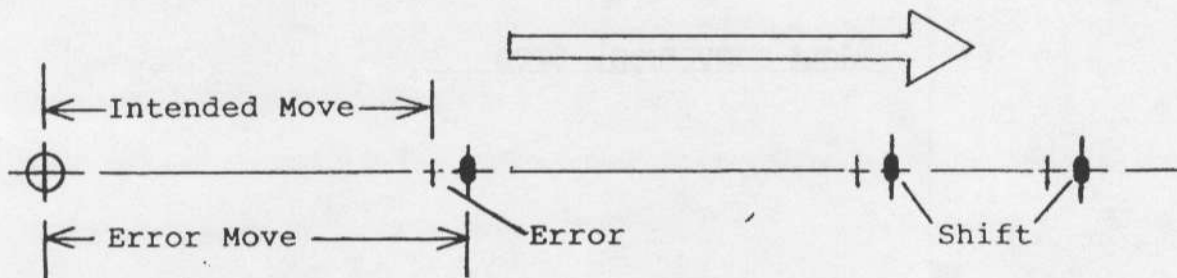
Advantages:

- Easier to understand
 - tends to think of tool movement in increments
 - each new move is new task
 - mathematics is less complicated

Disadvantages:

- Errors
 - if error is made, it will effect all future moves (accumulative error).

EACH POINT IS SHIFTED TO THE RIGHT BY .270



Absolute Values:

Advantages:

- no accumulative error.
- program is simplified if drawing uses base line or absolute dimensioning.

Disadvantages:

- mathematical computations create additional chance of error - addition and subtraction to find next point or a distance.
- more math must be done in general when using this system.
- referring back to a baseline or absolute zero position is often more difficult for the beginning programmer.

Conclusion - Choose what saves the most math and fits the blueprint.

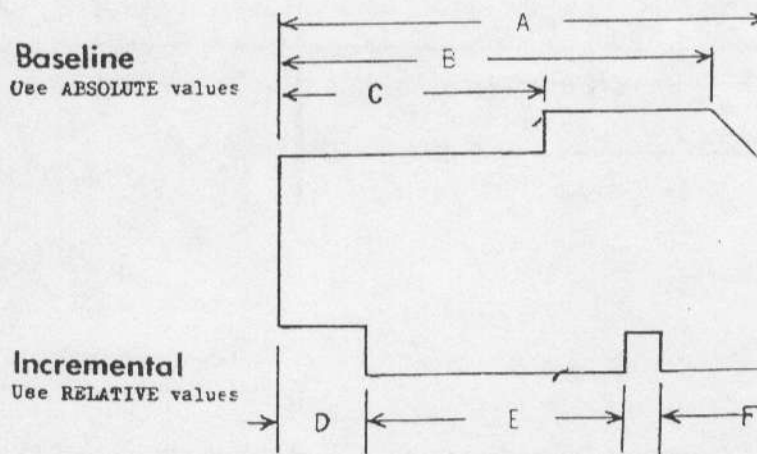
Choosing The Best Unit To Use:

Another name for relative values is INCREMENTAL because each dimension is a new distance of its own with no direct connection to the baseline. In the drawing below, some of the dimensions are incremental. If relative values are chosen for the point identifications there would be no arithmetic, yet some calculations would have to be done if absolute values were chosen.

On the other hand, some of the dimensions come from a baseline and they would be easy to program using absolute values. These points would be difficult to program in relative values because they would require some math.

LET THE BLUEPRINT DICTATE THE PROGRAM UNITS

WHICH UNIT ?

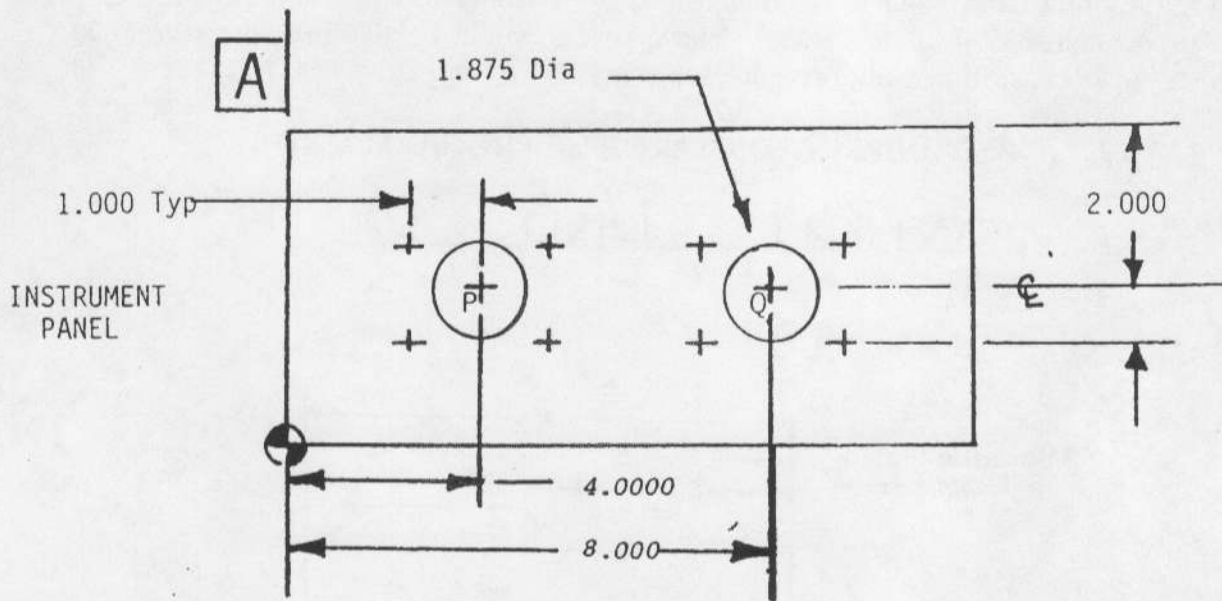


MIXING VALUES IN A SINGLE PROGRAM

A good example of a job that would best be programmed by mixing point values would be the instrument panel on page 8. The center of the two large round instrument cutouts refers back to the baseline Datum "A". This would be programmed in absolute values. Next, there would be a need to add and subtract the values for the small four hole locations around each cutout if remaining in absolute programming. A better way would be to then create a local reference point and use the relative distances while referring to these points.

The local reference points in the drawing would be points "P" and "Q"

INSTRUMENT PANEL

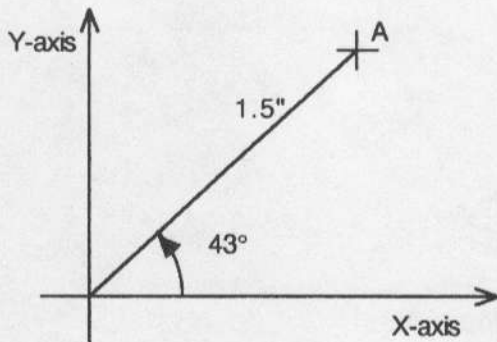


To move from PRZ to point "P" and to point "Q", absolute values would be used, but to program the details in each pattern relative values would be best.

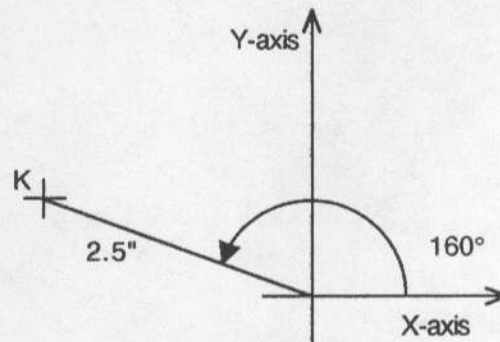
This kind of free flowing programming is a modern way to avoid needless errors and math. This technique will be repeatedly suggested throughout the course.

POLAR COORDINATE SYSTEM

Instead of always programming in the Cartesian coordinate system, the operator may choose for convenience to write an entire or partial program in the **polar coordinate system**. Polar coordinates use concentric circles as their reference lines, with the zero point at the center. These circular lines represent the radial distance from the center to the given point. The other locating factor about a given point is how many degrees it is to the point from the **polar reference line**. The polar reference line is the positive X-axis, and is always at the 3 o'clock position from the center point. Given the **radius** and **angle**, any point on the X-Y plane can be identified.

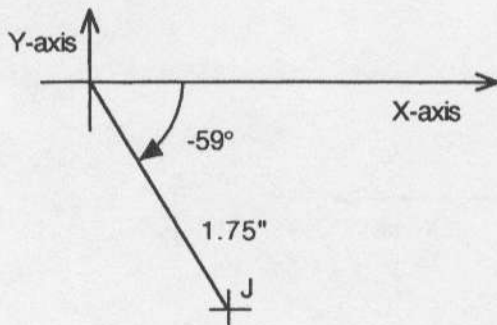


Example 1. Point A is identified at:
Radius = 1.5" Angle = 43°

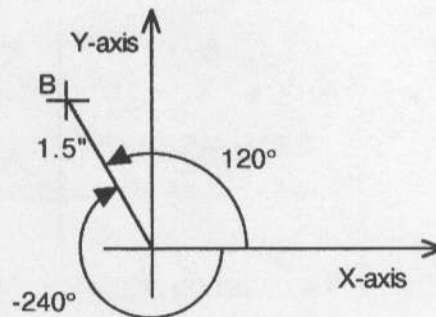


Example 2. Point K is identified at:
Radius = 2.5" Angle = 160°

The angles in examples 1 and 2 were measured in a counter-clockwise direction. The angle is positive if it is counter-clockwise from the positive X-axis. If it is clockwise from this axis, the angle is negative.



Example 3. Point J is identified at:
Radius = 1.75" Angle = -59°



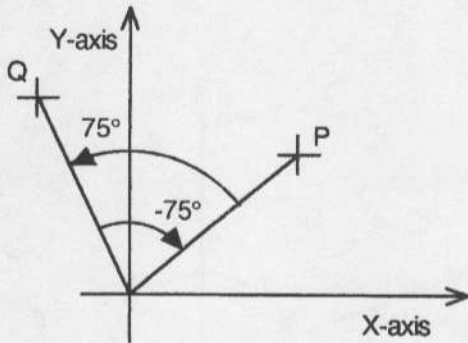
Example 4. Point B is identified at:
Radius = 1.5" Angle = 120°, or
Radius = 1.5" Angle = -240°

Using polar coordinates, the machine can be directed to move on a circular path. The direction in which the machine goes depends upon the sign of the angle given. If a positive angle is given, the machine will go in a counter-clockwise direction. If the angle is negative, the direction will be clockwise.

Absolute angles are called out on the display in relation to the *polar reference line* (positive X-axis or 3 o'clock position).

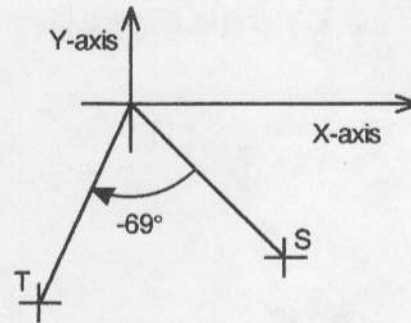
Relative angles are not measured from the reference axis, but from the *previous point*.

This difference is similar to the difference between absolute and relative distances in the Cartesian coordinate system. The sign of a relative angle determines the direction from one point to another; positive counterclockwise, and negative clockwise (as for absolute angles).



Example 5.

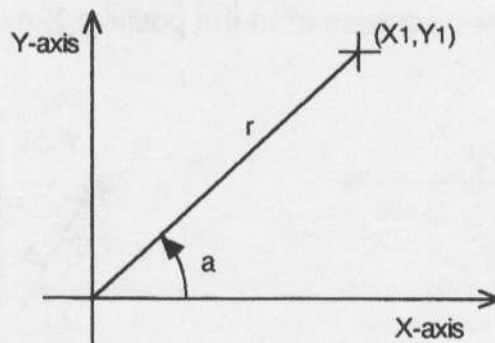
Angle from point P to point Q = 75°
 Angle from point Q to point P = -75°



Example 6.

Angle from point S to point T = -69°

Two formulas to remember:-



To find the radius distance (r);

$$r = \sqrt{(X_1^2 + Y_1^2)}$$

To find the angle distance (a) from the positive X-axis (3 o'clock);

$$a = \tan^{-1}(Y_1/X_1)$$