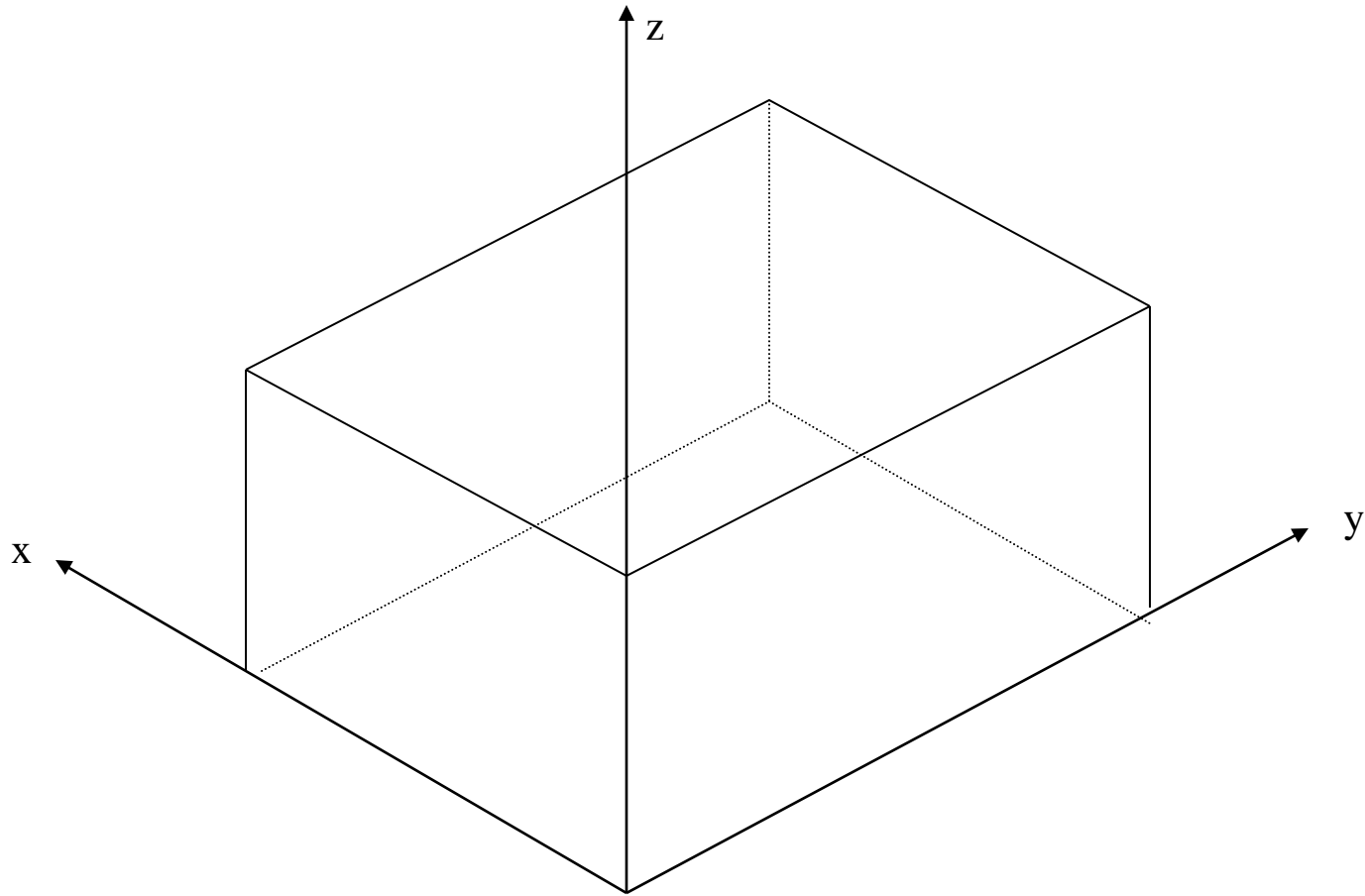


Part will be defined in the Cartesian coordinate system as shown in fig.1.



Part Programming

APT (Automatically Programmed Tool) is a software compiler for simplifying numerical control Programming.

Developed by MIT in 1959

APT is the most widely used processor

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Developed by MIT in 1959

APT is the most widely used processor

APT Characteristics

Three-dimensional unbounded surfaces and points are defined to represent the part to be made •

Surfaces are defined in a X-Y-Z coordinate system •

In Programming, the tool does all the moving; the part is stationary. •

Linear interpolation is used for curved tool paths •

APT Statement Types (5)

Identification•

Geometry•

Motion•

Postprocessor (feed, speed, coolant, ... •
etc.)

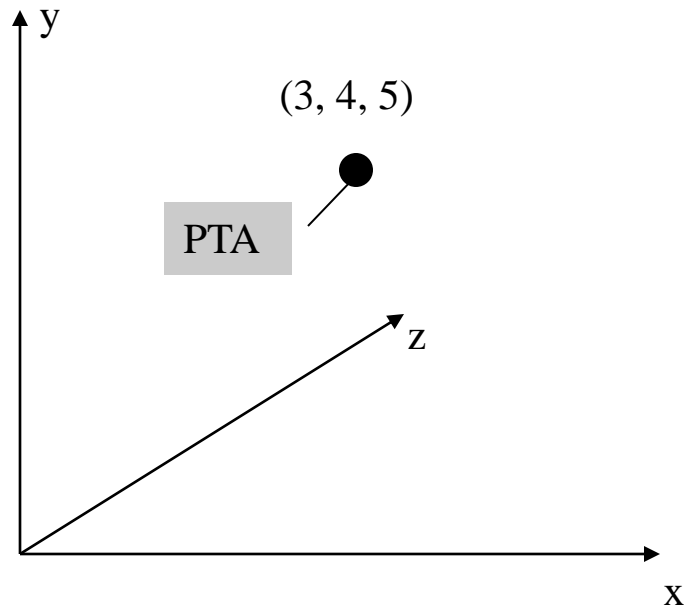
Auxiliary (tool, tolerance, part, ... etc.)•

The general format for geometric statements is:

$\langle \text{Symbol} \rangle = \text{Geometric Type/ Definitional}$
 Modifiers

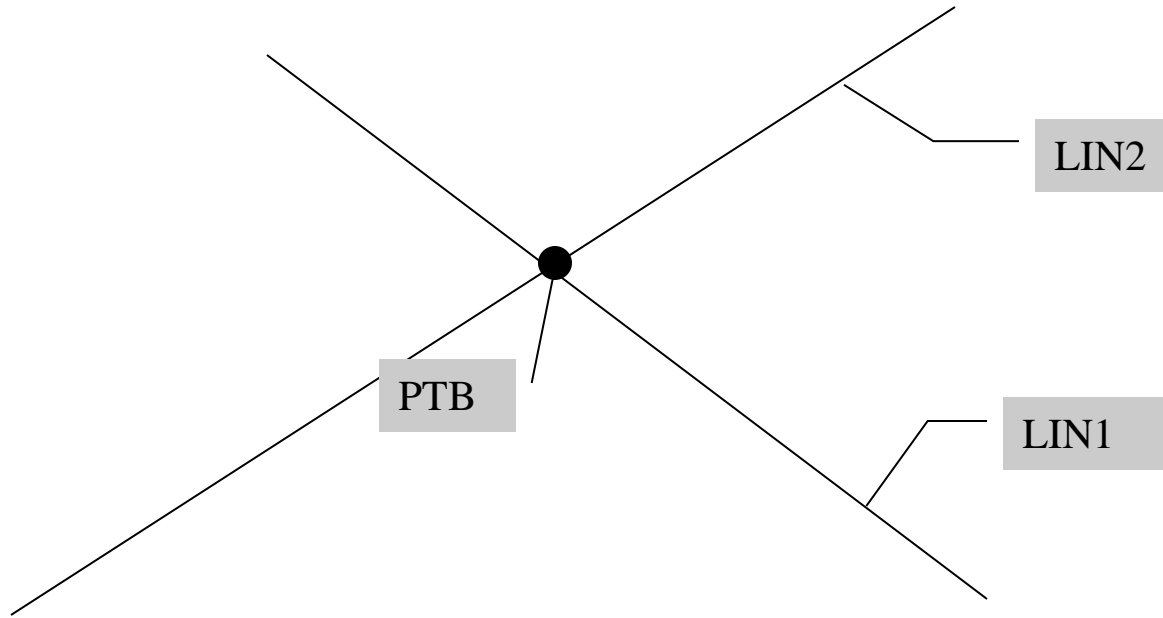
Point (POINT)

PTA = POINT/ 3,4,5



Point (POINT)

PTB = POINT/ INTOF, LIN1, LIN2



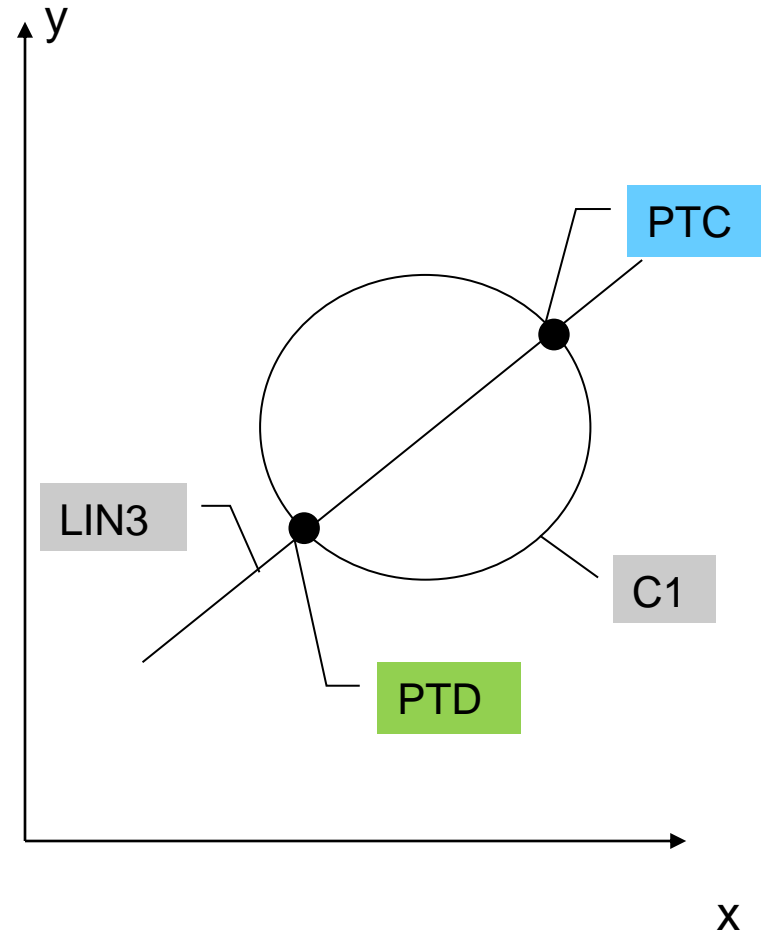
Point (POINT)

PTD = POINT/ YSMALL, INTOF, LIN3, C1

PTD = POINT/ XSMALL, INTOF, LIN3, C1

PTC = POINT/ YLARGE, INTOF, LIN3, C1

PTC = POINT/ XLARGE, INTOF, LIN3, C1



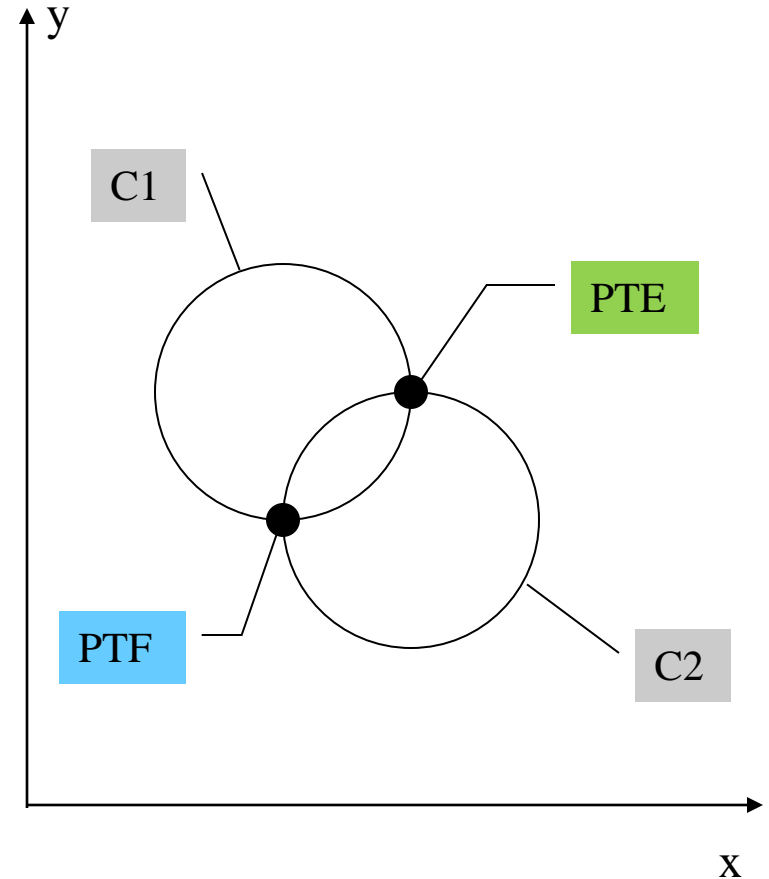
Point (POINT)

PTE = POINT/ YLARGE, INTOF, C1, C2

PTE = POINT/ XLARGE, INTOF, C1, C2

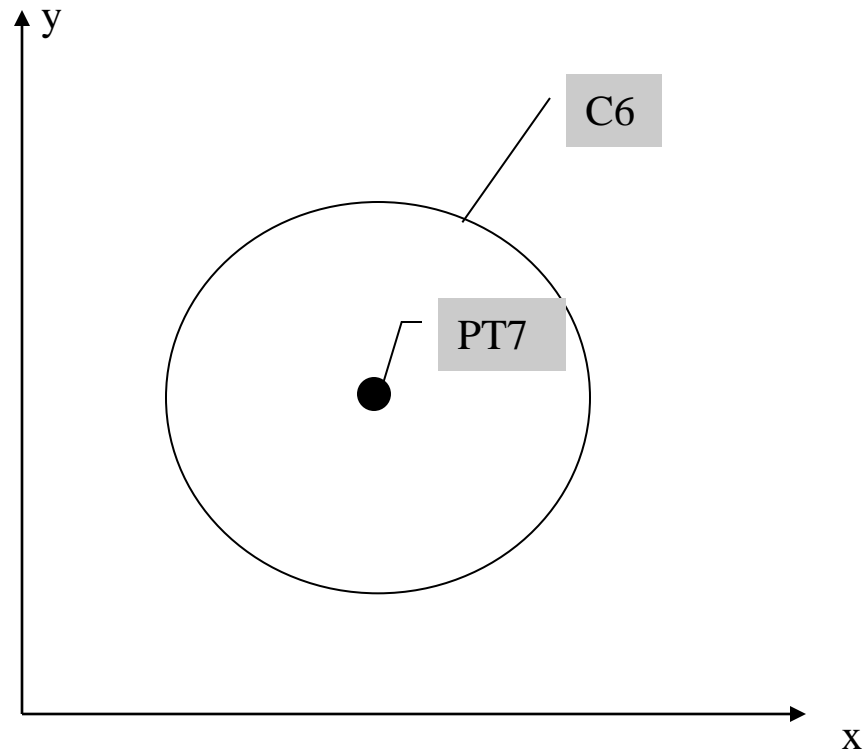
PTF = POINT/ YSMALL, INTOF, C1, C2

PTF = POINT/ XSMALL, INTOF, C1, C2



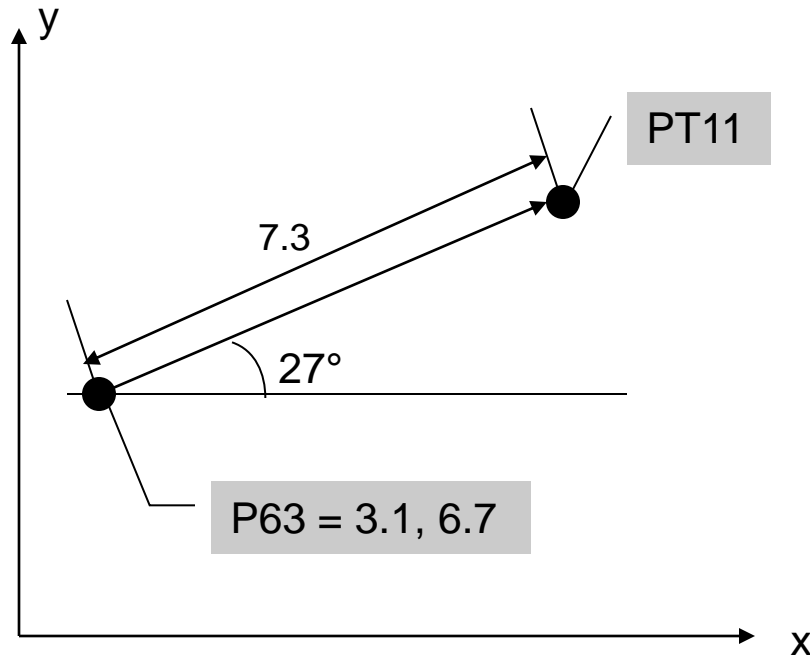
Point (POINT)

PT7 = POINT/ CENTER, C6



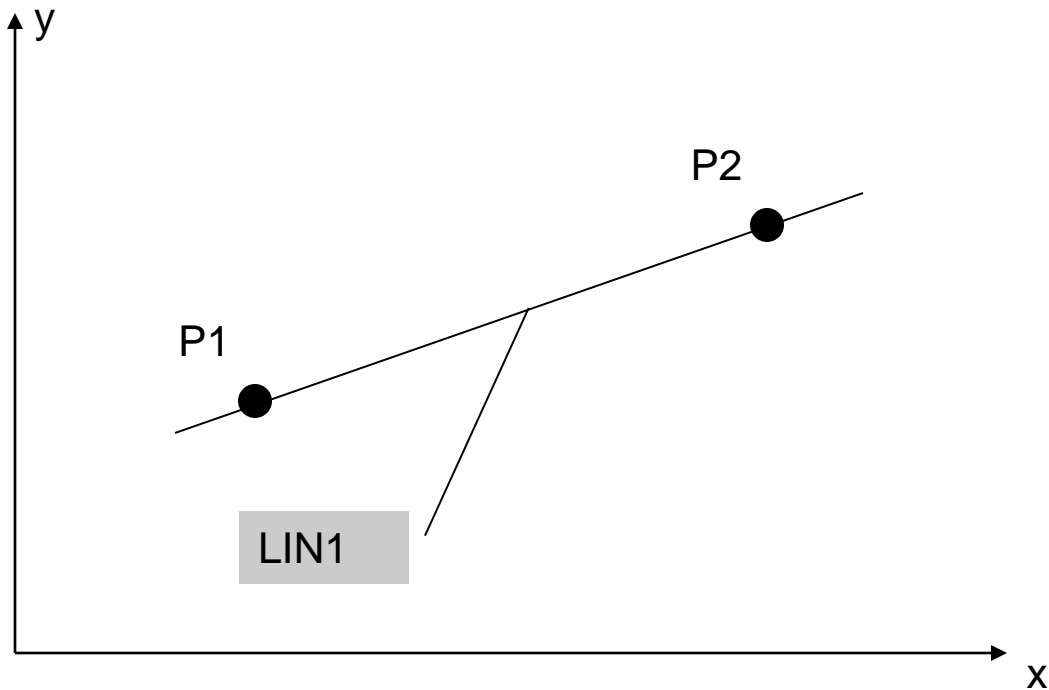
Point (POINT)

PT11 = POINT/ P63, RADIUS, 7.3, ATANGLE, 27



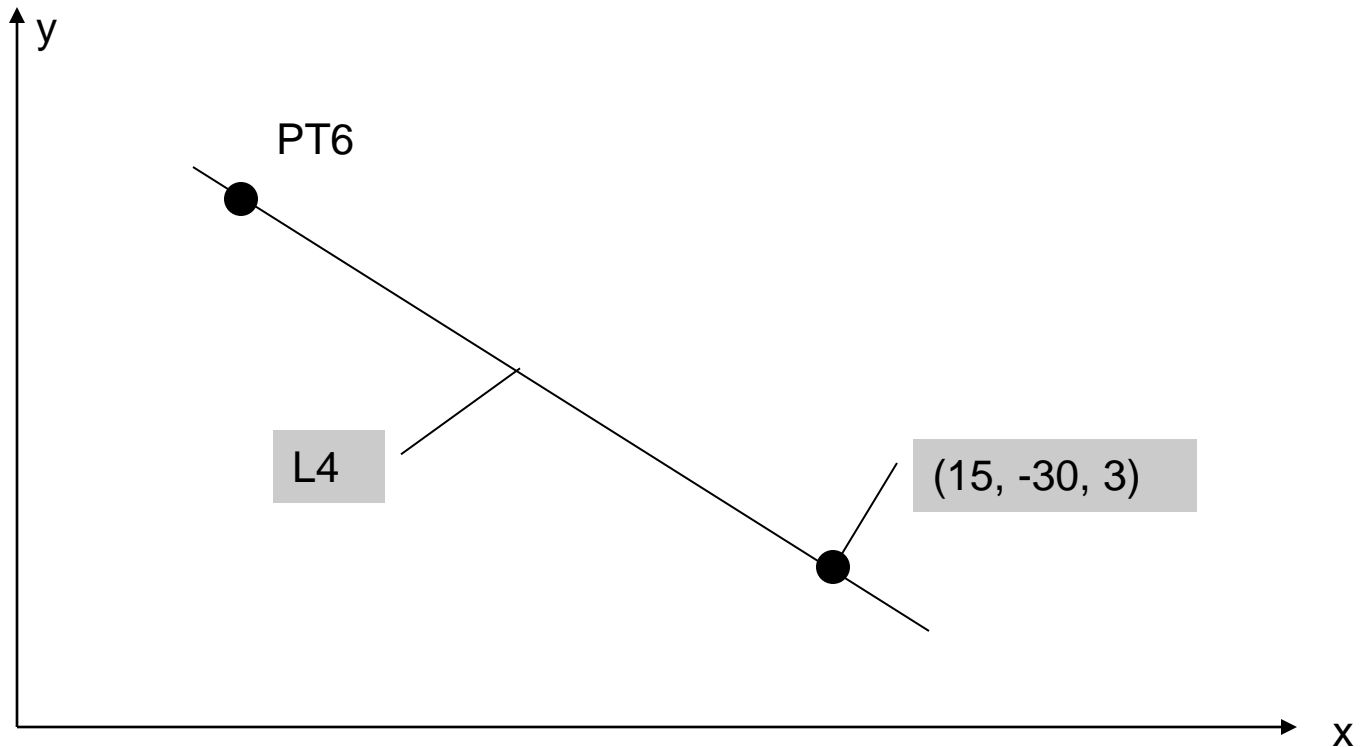
Line (LINE)

$\text{LIN1} = \text{LINE} / \text{P1, P2}$



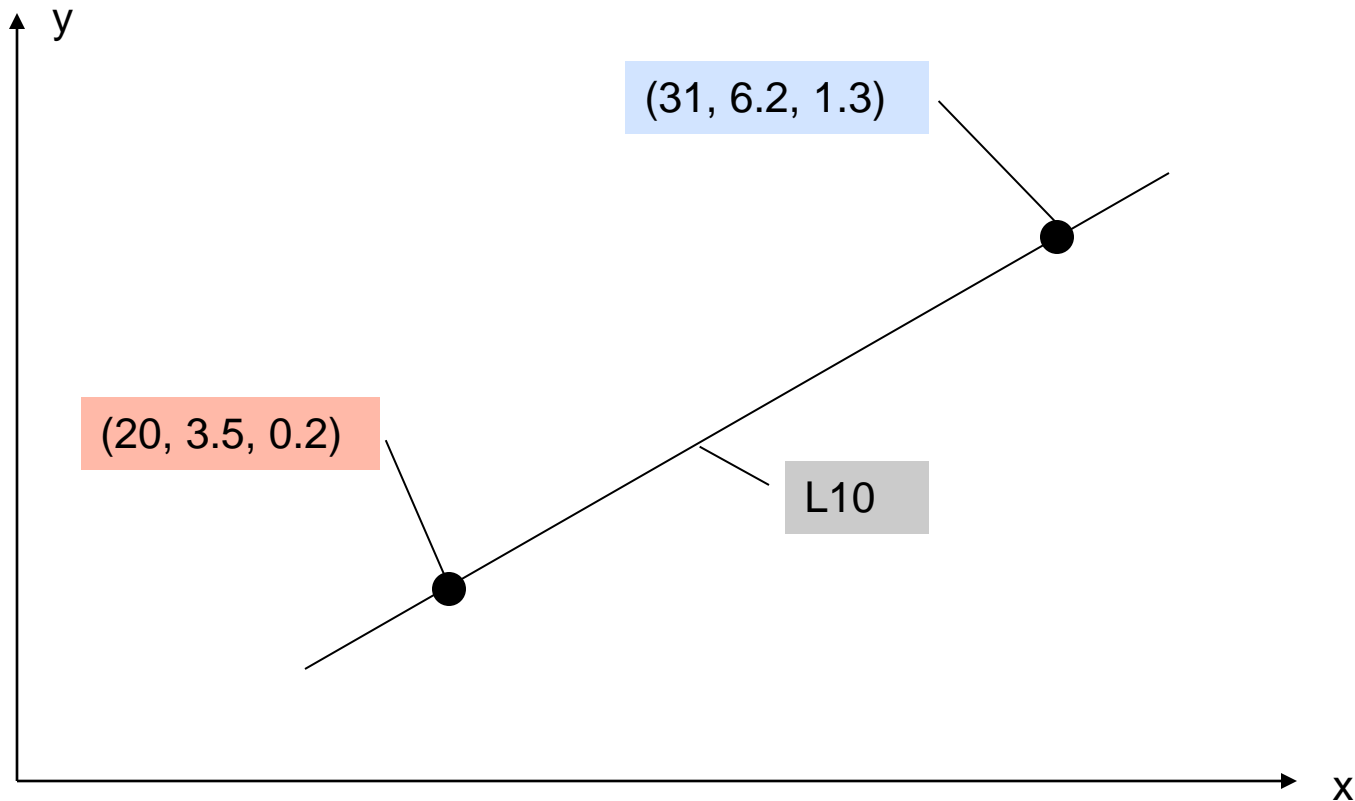
Line (LINE)

LIN4 = LINE/ PT6, 15, -30, 3



Line (LINE)

LIN10 = LINE/ 20, 3.5, 0.2, 31, 6.2, 1.3



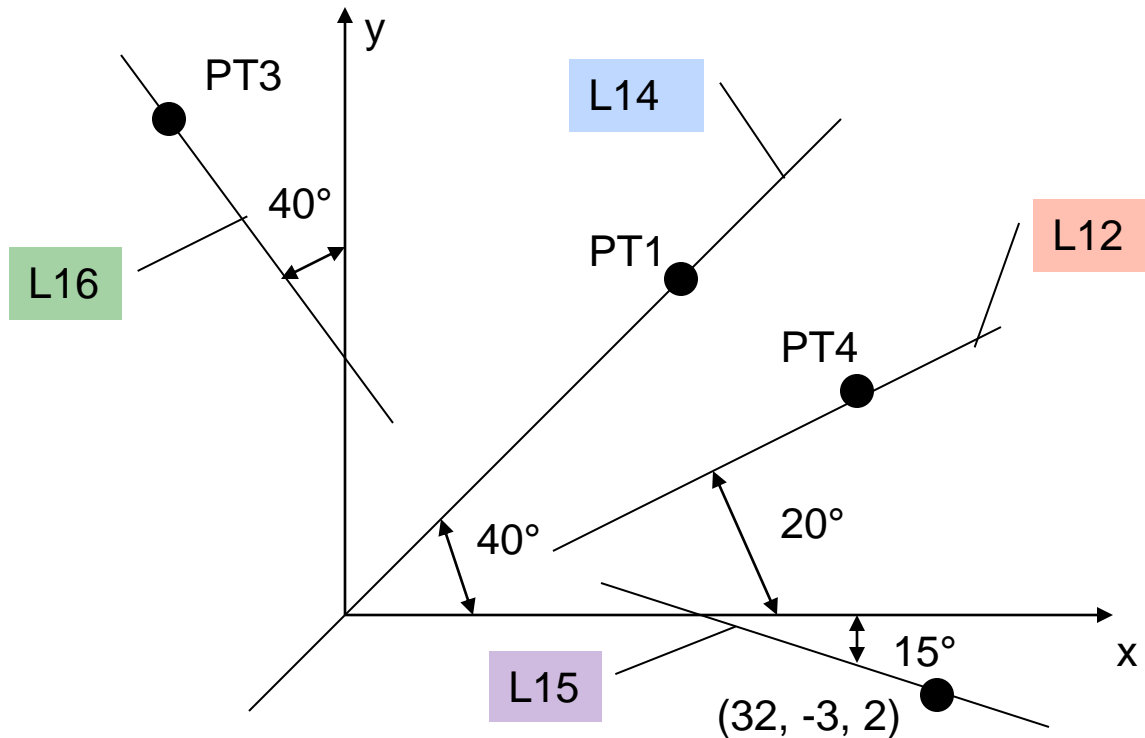
Line (LINE)

L12 = LINE/ PT4, ATANGL, 20, XAXIS

L14 = LINE/ PT1, ATANGL, 40

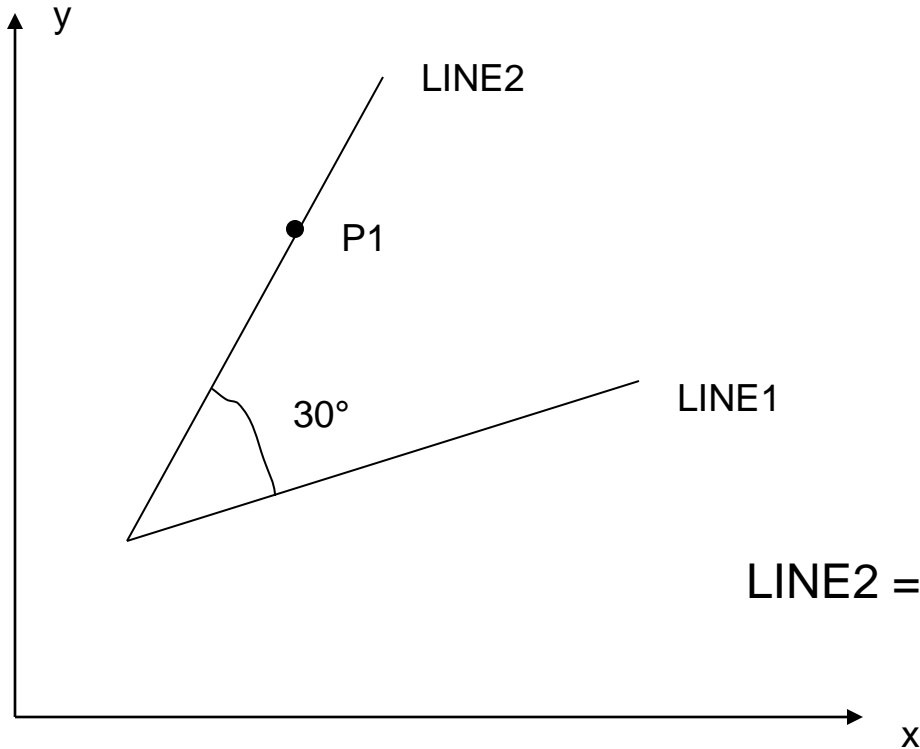
L15 = LINE/ 32, -3, 2, ATANGL, -15, XAXIS

L16 = LINE/ PT3, ATANGL, 40, YAXIS



Line (LINE)

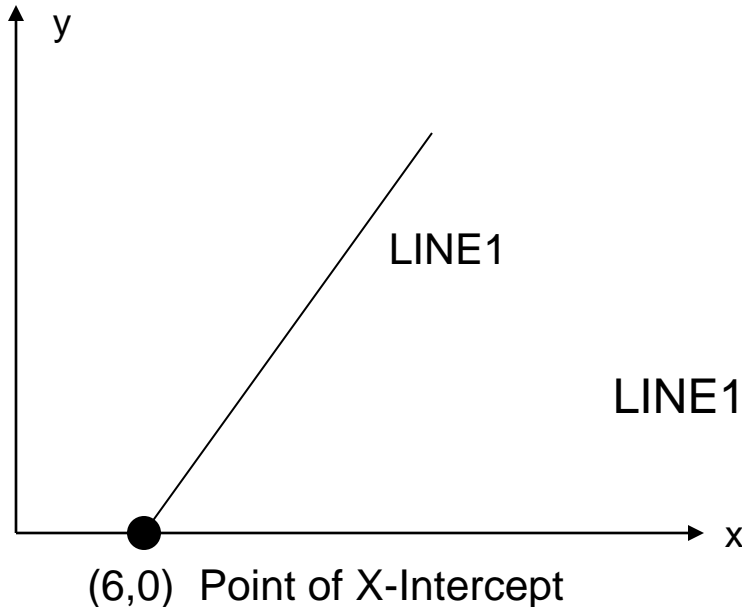
`LIN = LINE/ POINT, ATANGL, ANGLE (in degrees), LINE`



`LINE2 = LINE/ P1, ATANGL, 30, LINE1`

Line (LINE)

$LIN = LINE / SLOPE, SLOPE\ VALUE, INTERC, MODIFIER, d$
where the slope value is y/x . The modifier options are [XAXIS, YAXIS], and d is the corresponding **intercept** value on the selected axis (i.e., modifier).

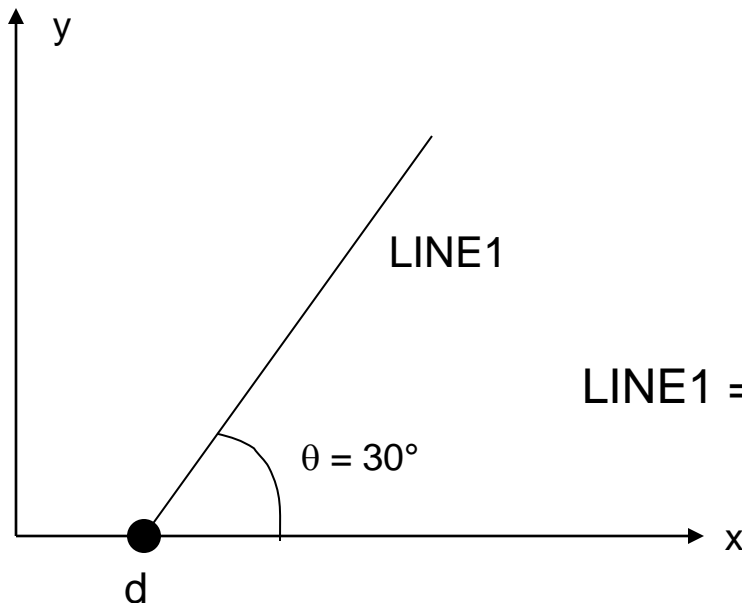


$LINE1 = LINE / SLOPE, 1, INTERC, XAXIS, 6$

Line (LINE)

`LIN = LINE/ ATANGL, DEGREES, INTERC, MODIFIER, d`

The modifier options are [XAXIS, YAXIS], and d is the corresponding intercept value on the selected axis (i.e., modifier).

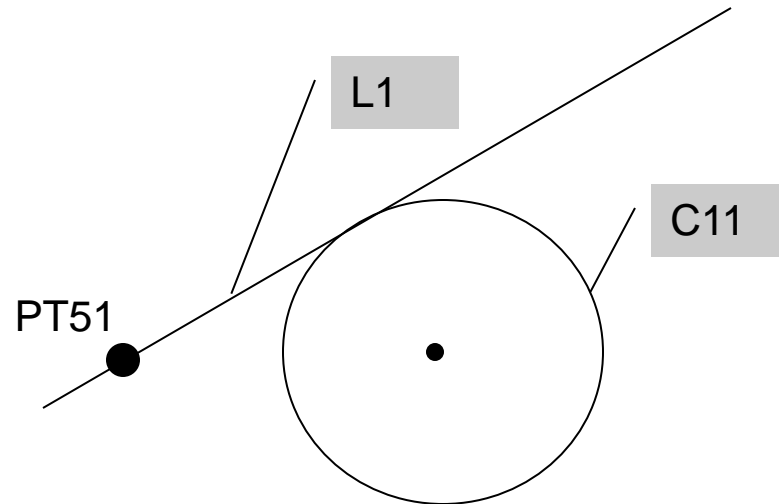


`LINE1 = LINE/ ATANGL, 30, INTERC, XAXIS, d`

Line (LINE)

The **LEFT** & **RIGHT** modifier indicates whether the line is at the left or right tangent point, depending on how one looks at the circle from the point.

L1 = LINE/ PT51, LEFT, TANTO, C11

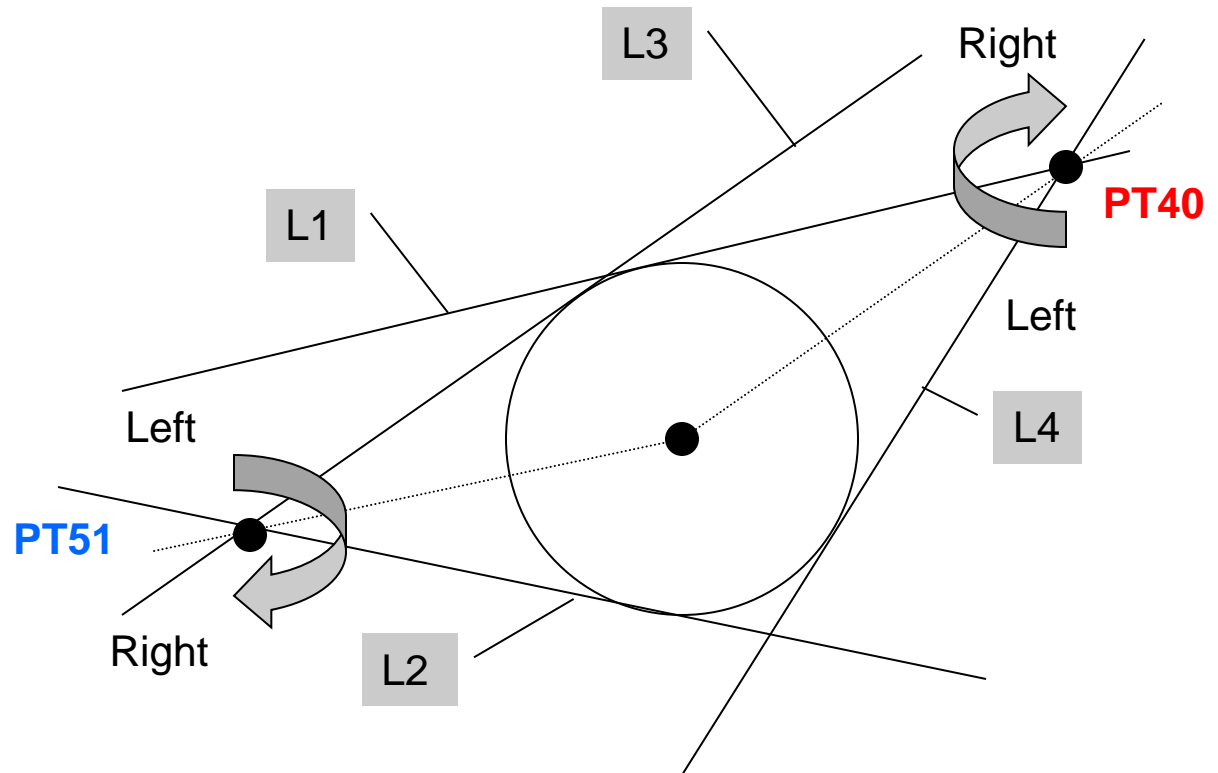


Line (LINE)

L2 = LINE/ PT51, RIGHT, TANTO, C11

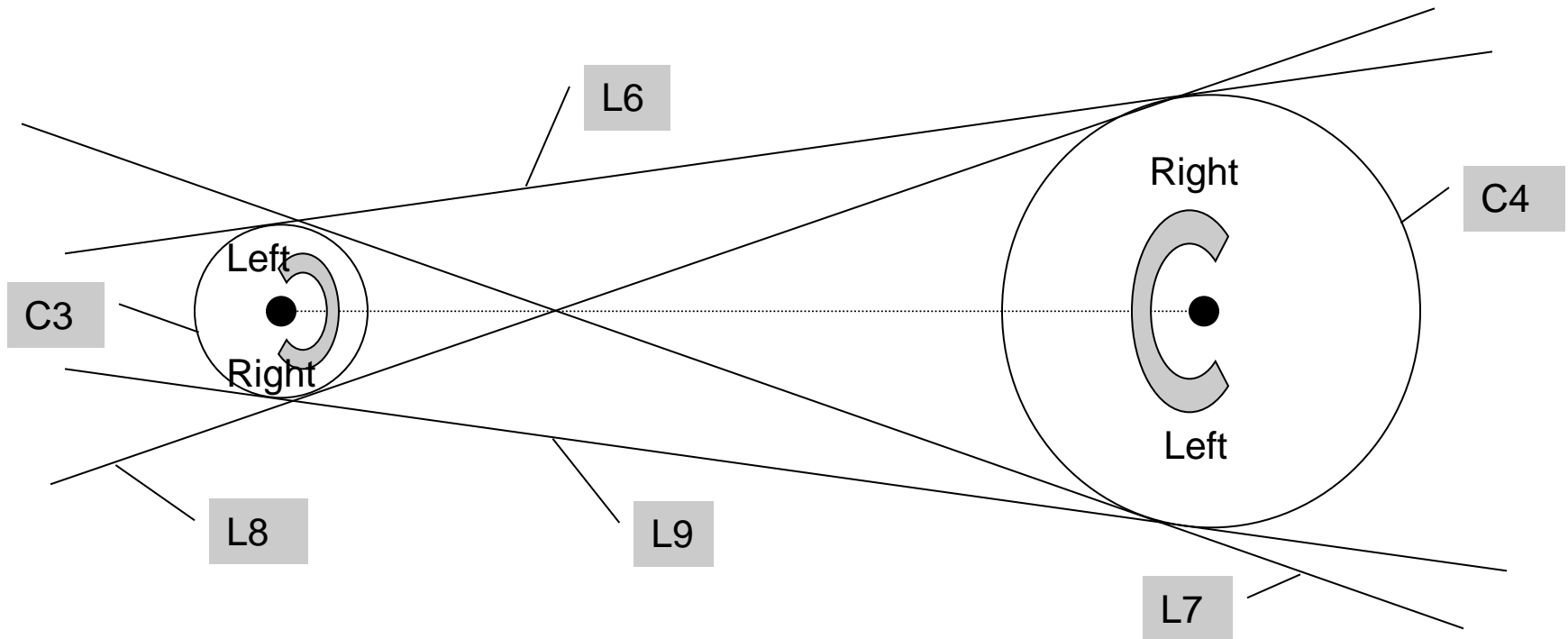
L1 = LINE/ PT40, RIGHT, TANTO, C11

L4 = LINE/ PT40, LEFT, TANTO, C11



Line (LINE)

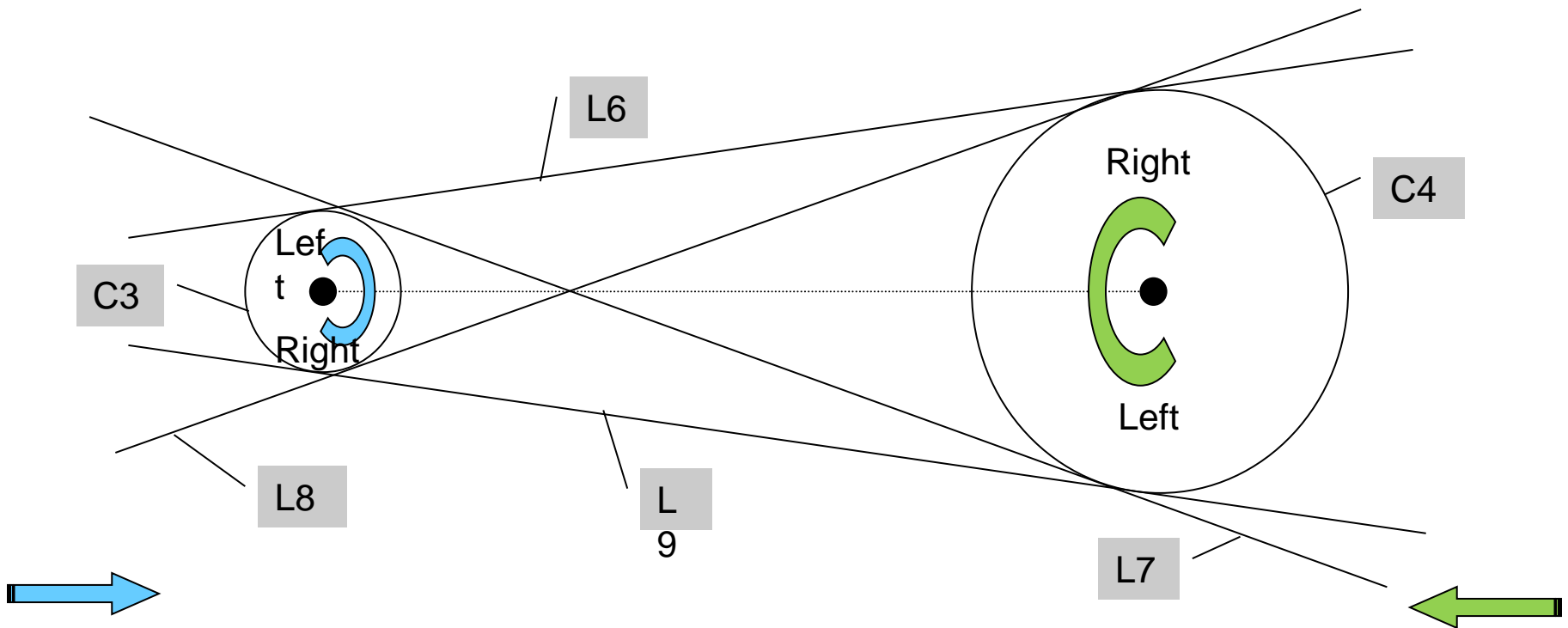
L6 = LINE/ LEFT, TANTO, C3, LEFT, TANTO, C4



Line (LINE)

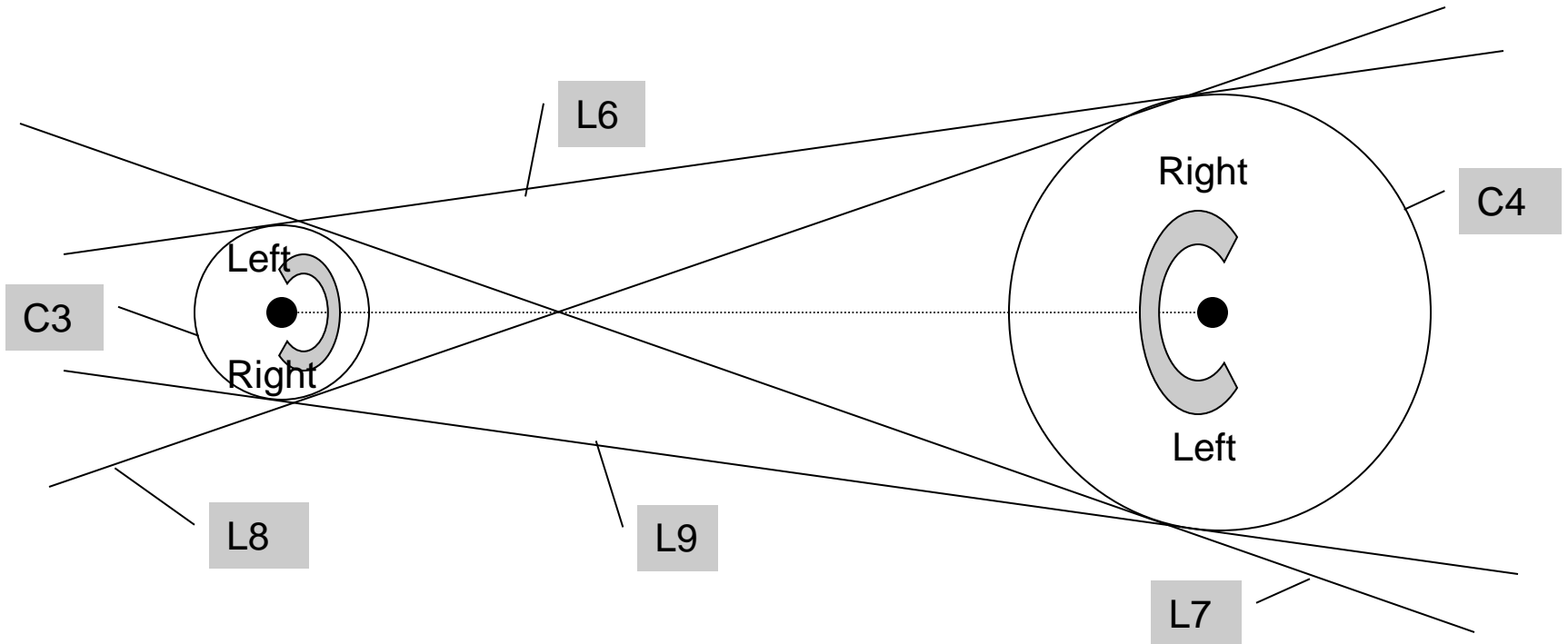
L7 = LINE/ LEFT, TANTO, C3, RIGHT, TANTO, C4

L7 = LINE/ LEFT, TANTO, C4, RIGHT, TANTO, C3



Line (LINE)

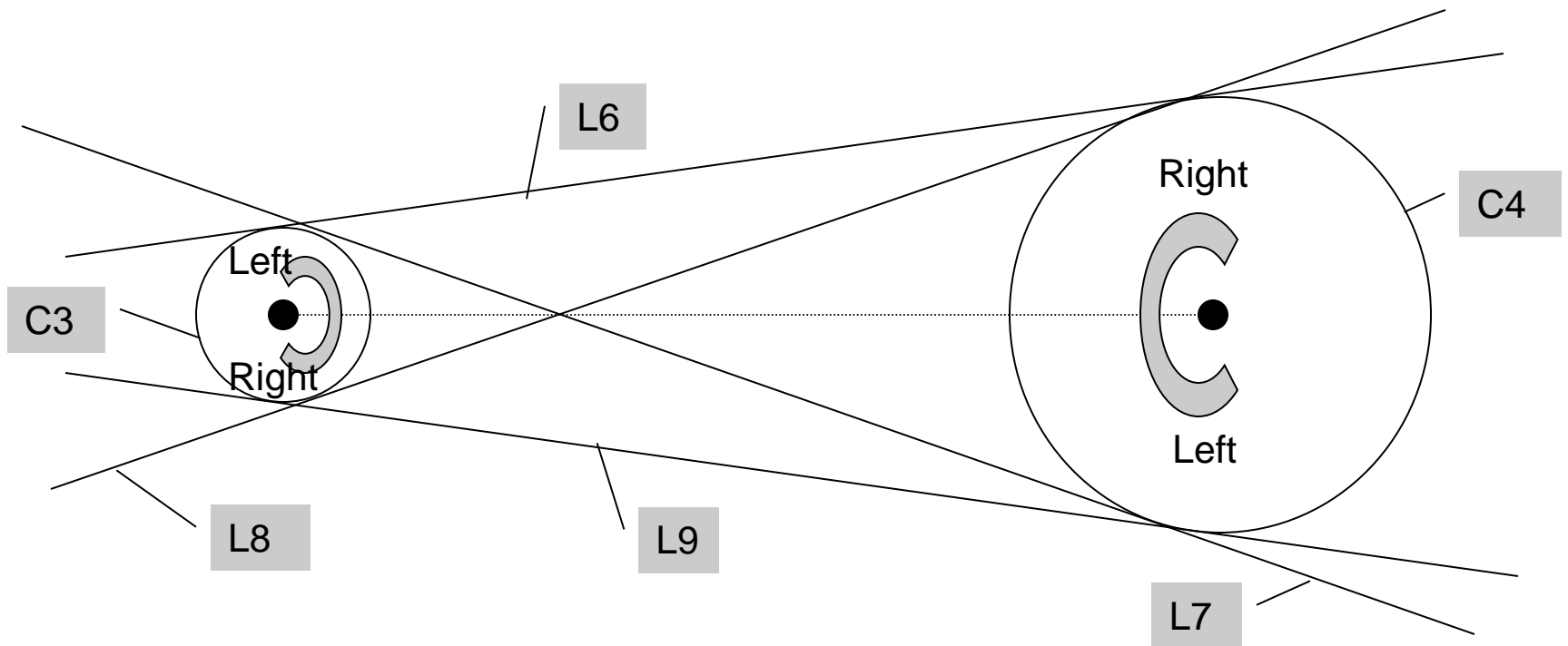
L8 = LINE/ RIGHT, TANTO, C3, LEFT, TANTO, C4



Line (LINE)

L9 = LINE/ RIGHT, TANTO, C3, RIGHT, TANTO, C4

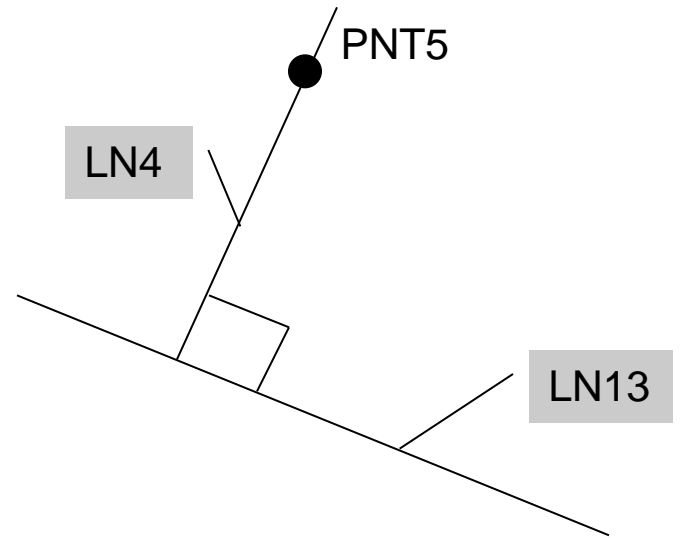
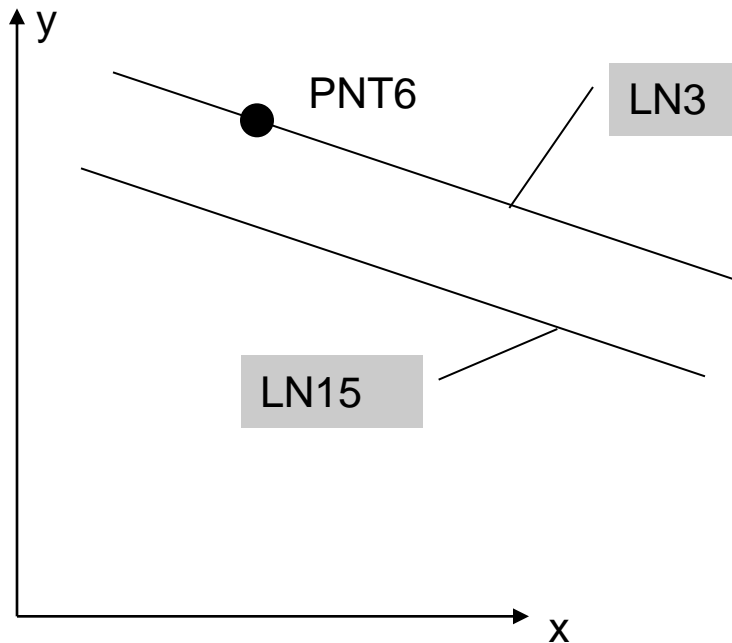
L9 = LINE/ LEFT, TANTO, C4, LEFT, TANTO, C3



Line (LINE)

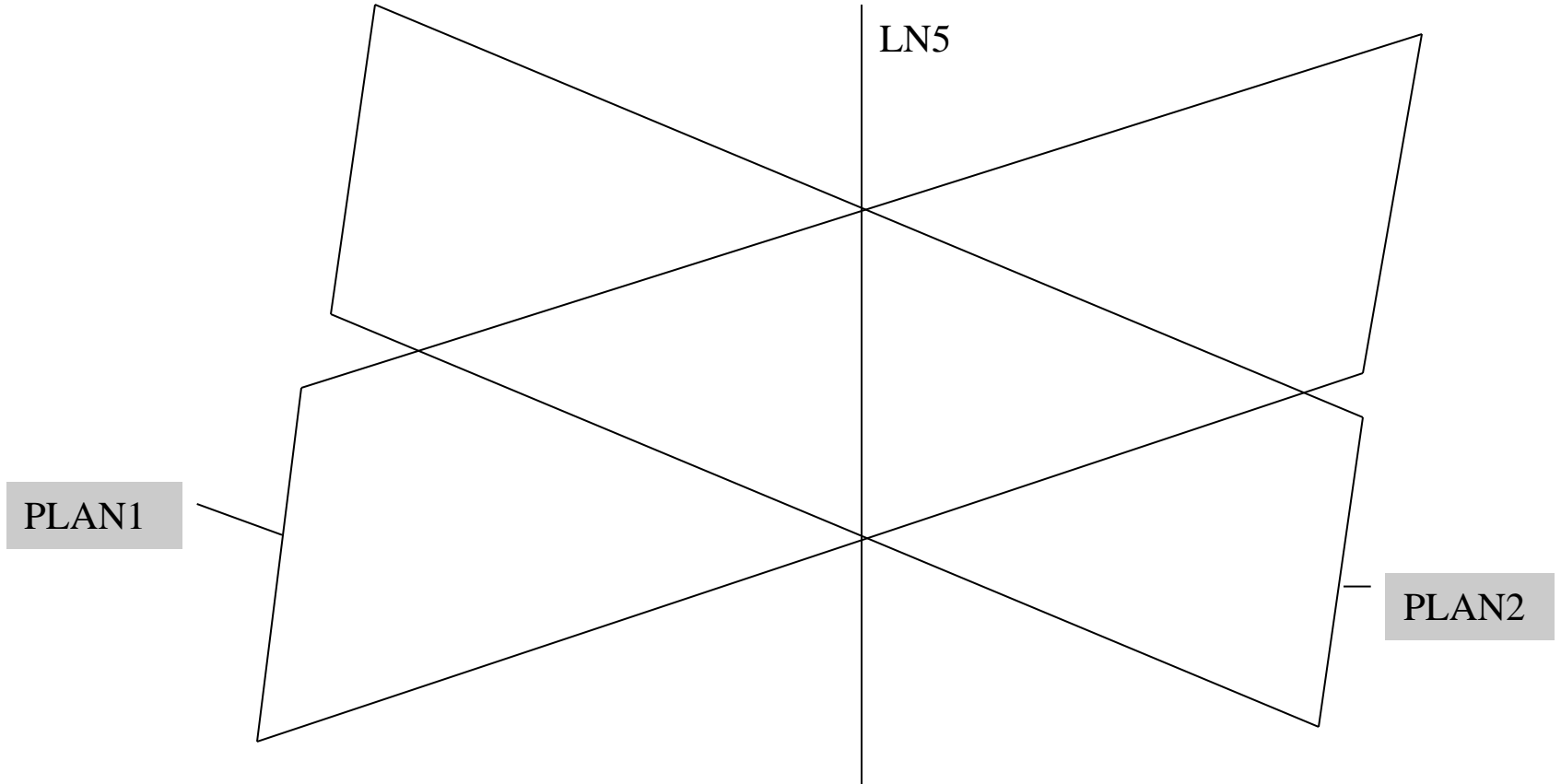
LN3 = LINE/ PNT6, PARLEL, LN15

LN4 = LINE/ PNT5, PERPTO, LN13



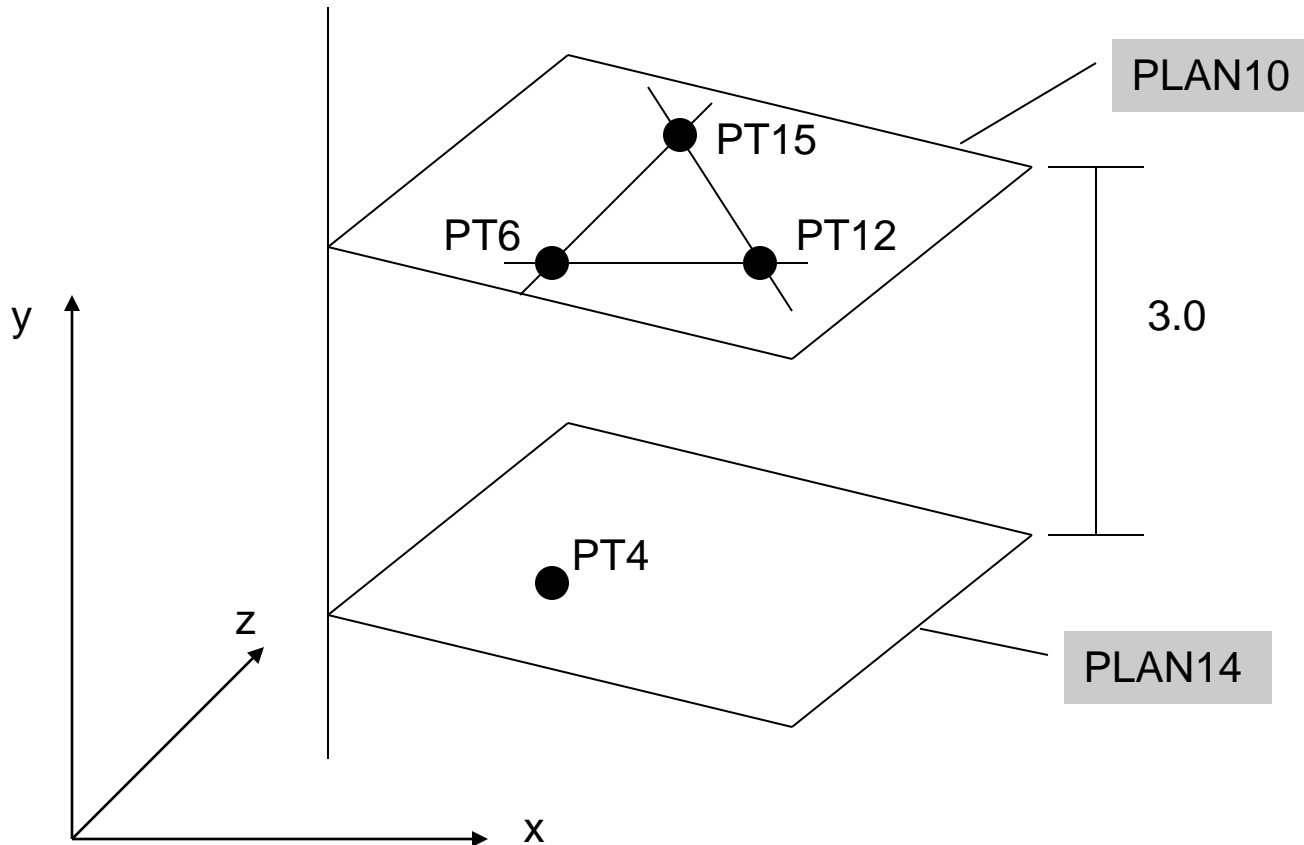
Plane (PLANE)

LN5 = LINE/ INTOF, PLAN1, PLAN2



Plane (PLANE)

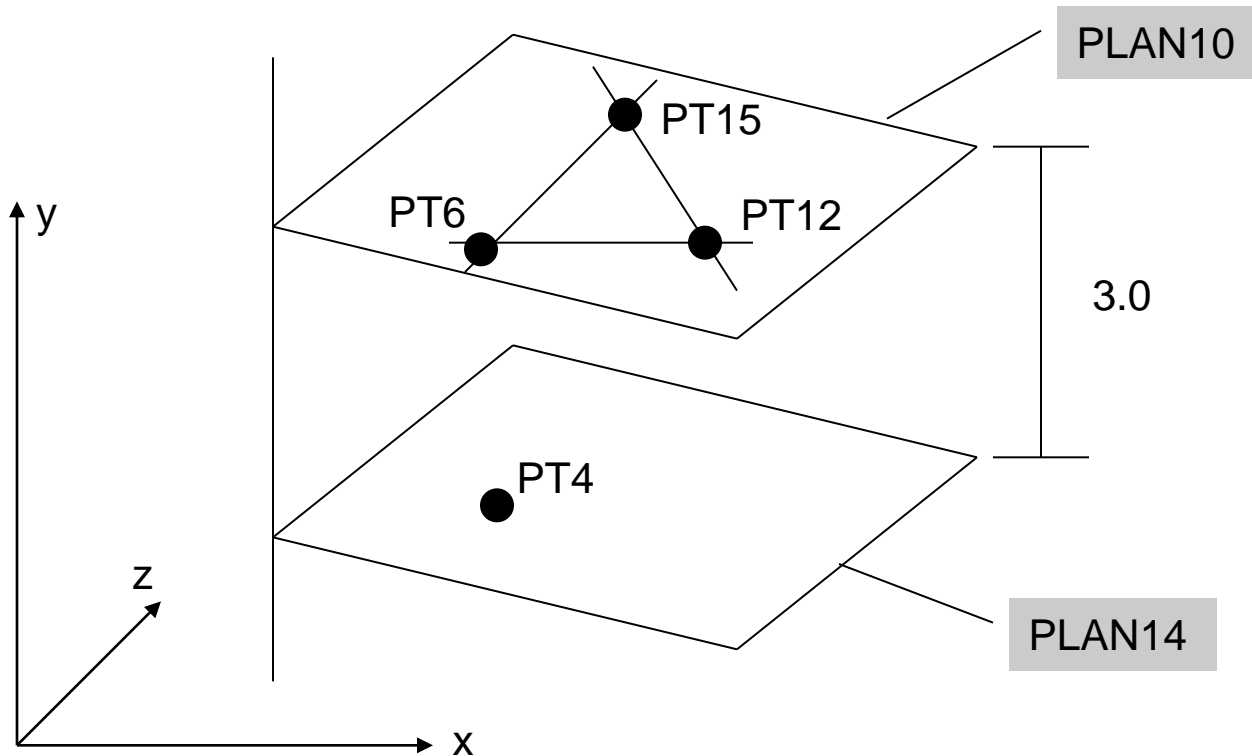
PLAN10 = PLANE/ PT6, PT12, PT15



Plane (PLANE)

PLAN14 = PLANE/ PT4, PARLEL, PLAN10

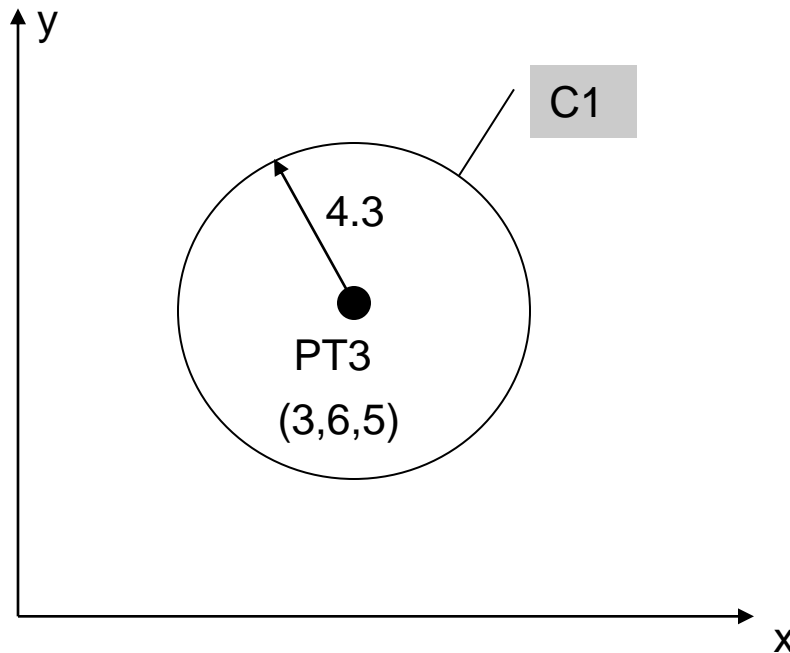
PLAN14 = PLANE/ PARLEL, PLAN10, YSMALL, 3.0



Circle (CIRCLE)

$C1 = \text{CIRCLE} / 3, 6, 5, 4.3$

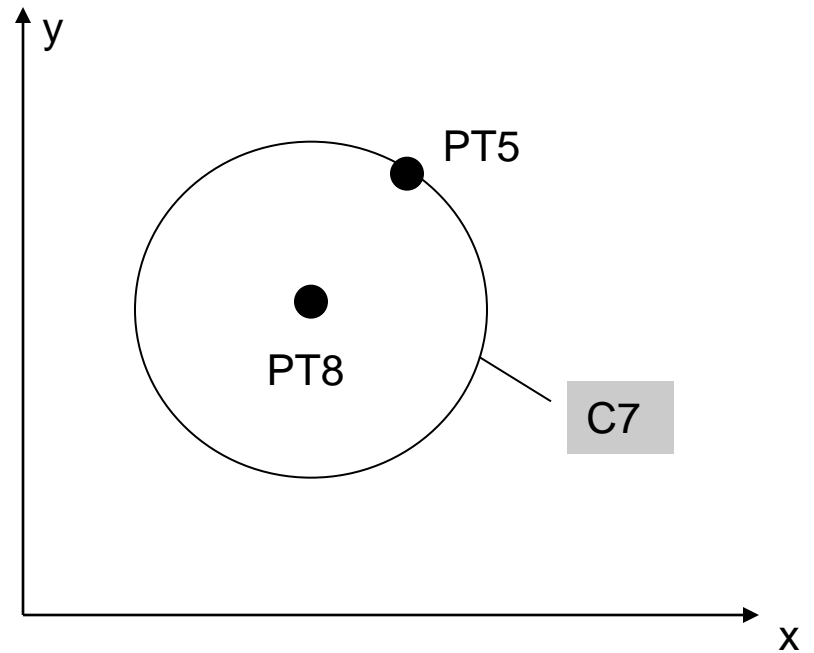
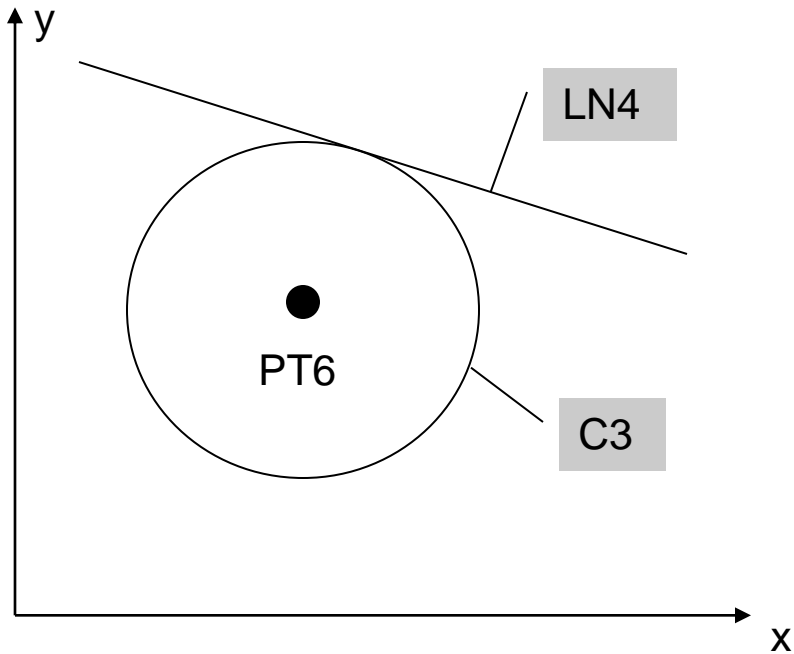
$C1 = \text{CIRCLE} / \text{CENTER}, \text{PT3}, \text{RADIUS}, 4.3$



Circle (CIRCLE)

C3 = CIRCLE/ CENTER, PT6, TANTO, LN4

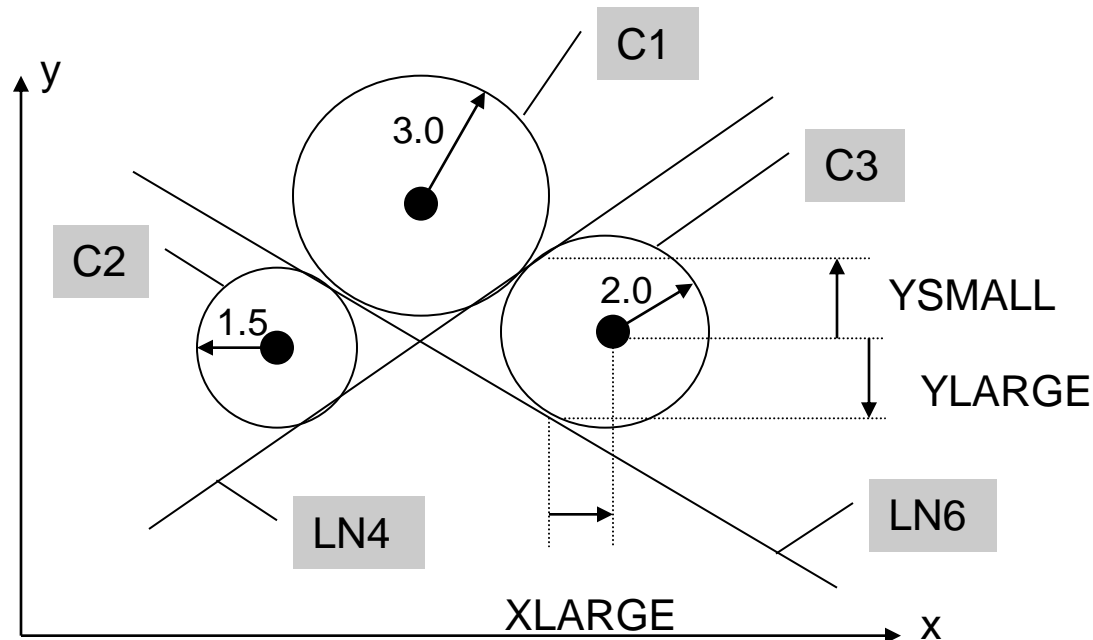
C7 = CIRCLE/ CENTER, PT8, PT5



Circle (CIRCLE)

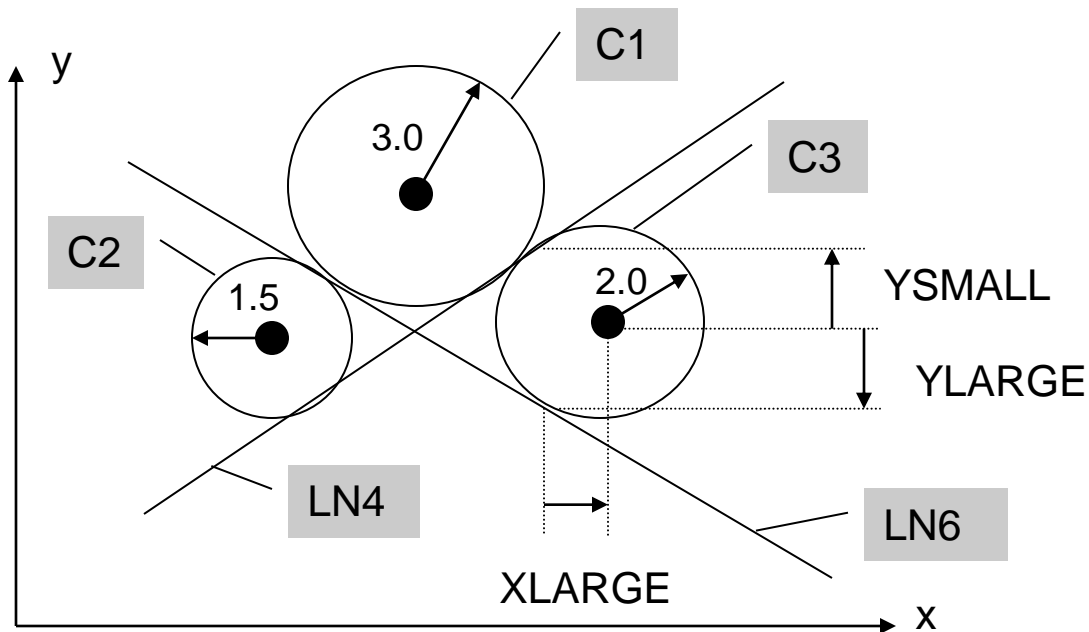
C3 = CIRCLE/ YLARGE, LN6, XLARGE, LN4, RADIUS, 2.0

C3 = CIRCLE/ XLARGE, LN6, YSMALL, LN4, RADIUS, 2.0



Circle (CIRCLE)

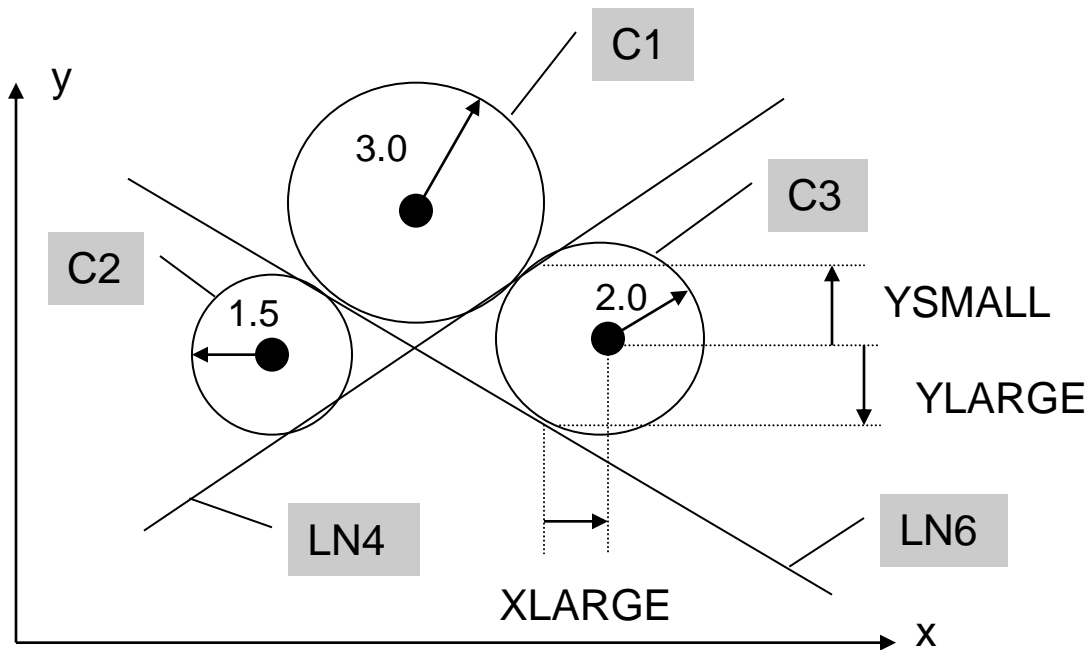
C1 = CIRCLE/ YLARGE, LN6, YLARGE, LN4, RADIUS, 3.0



Circle (CIRCLE)

C2 = CIRCLE/ XSMALL, LN6, XSMALL, LN4, RADIUS, 1.5

C2 = CIRCLE/ YLARGE, LN4, YSMALL, LN6, RADIUS, 1.5



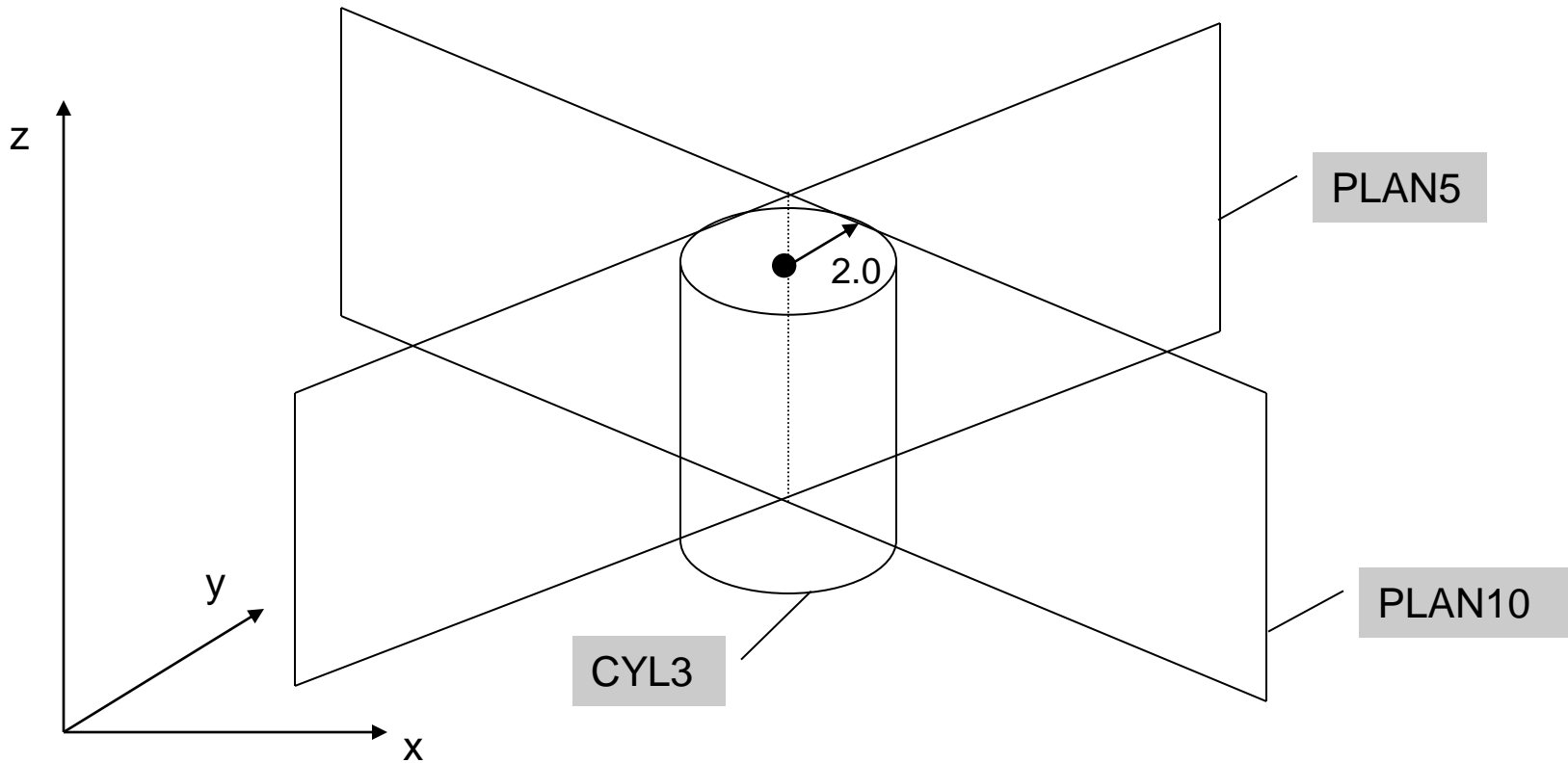
Cylinder (CYLNDR)

<Symbol> = CYLNDR/ <axis modifier>, TANTO, <1st plane>, <axis modifier>, TANTO, <2nd plane>, RADIUS, <radius value>

The axis modifier depends on the relationship of the cylinder center point to the tangent point of the plane the modifier precedes.

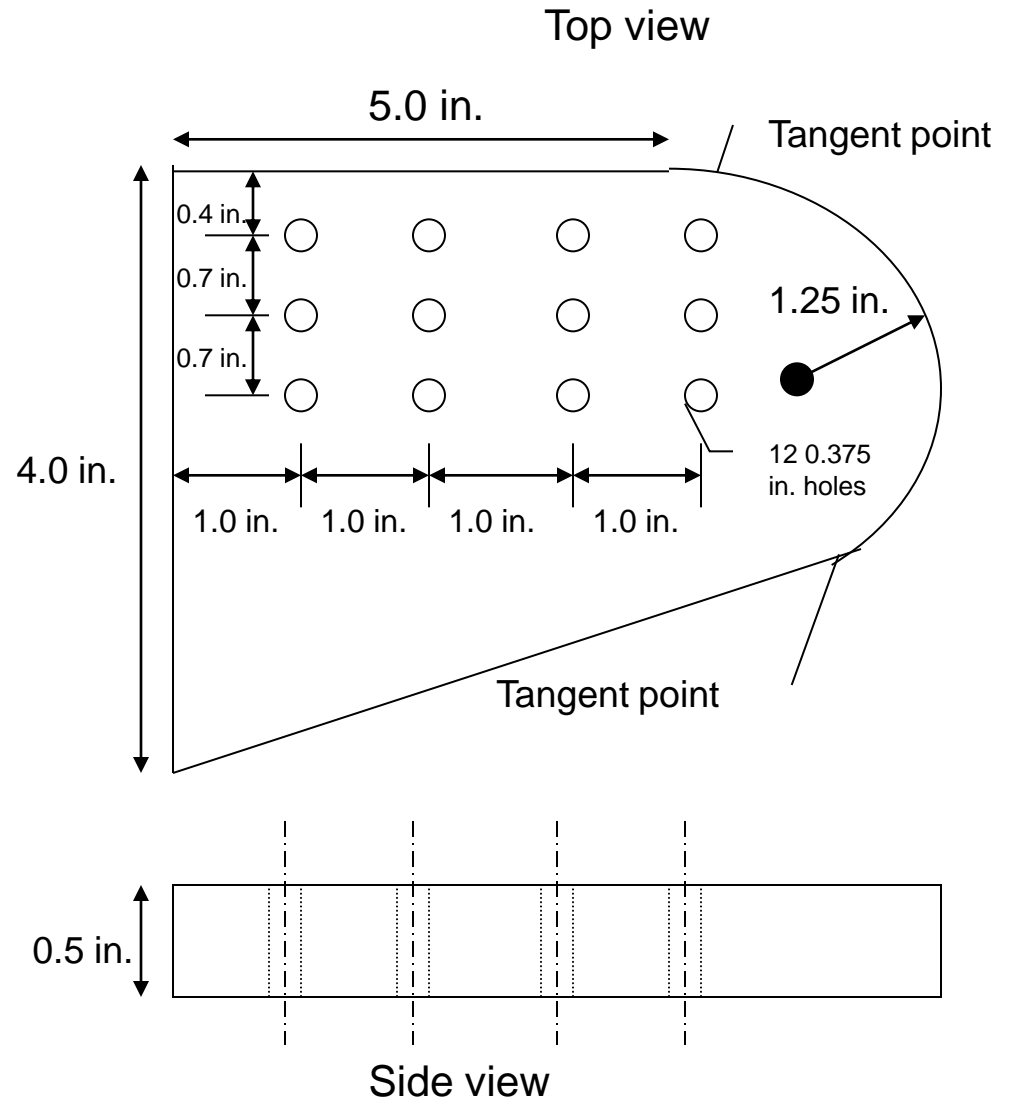
Cylinder (CYLNDR)

CYL3 = CYLNDR/ XLARGE, TANTO, PLAN5, YSMALL, TANTO, PLAN10, RADIUS, 2.0



Geometry Example

The top view of a plate is shown in the following figure. The outer shape of this plate is to be milled & the grid holes drilled. It is therefore necessary to define the geometry of the part, i.e. its outer shape & the location of the holes.



Geometry Example

PT1 = POINT/ 4, 5, 0

PT2 = POINT/ 5, 4.6, 0

PT3 = POINT/ 8, 4.6, 0

PT4 = POINT/ 8, 3.2, 0

PT5 = POINT/ 9, 3.75, 0

C1 = CIRCLE/ CENTER, PT5, RADIUS, 1.25

PT6 = POINT/ 4, 1, 0

L1 = LINE/ PT1, LEFT, TANTO, C1

L3 = LINE/ PT1, PT6

L2 = LINE/ PT6, RIGHT, TANTO, C1

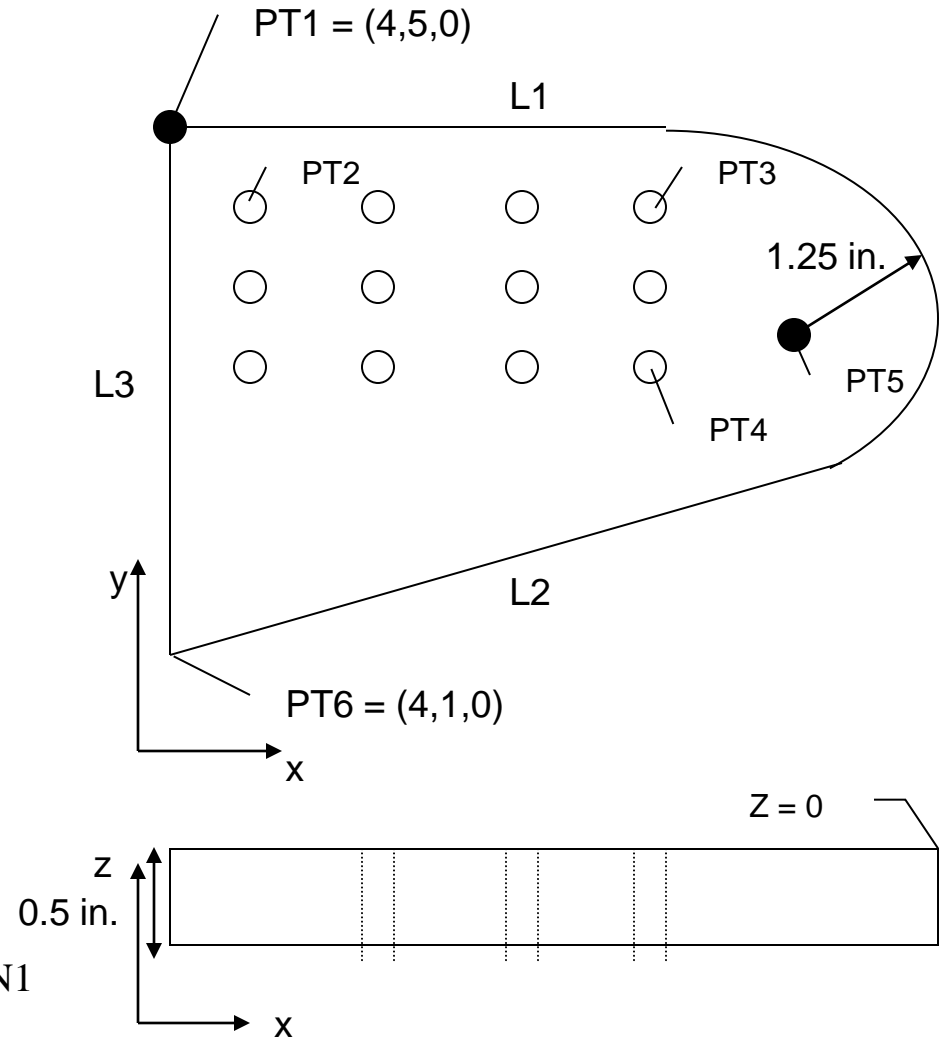
PLAN1 = PLANE/ PT1, PT2, PT3

PLAN2 = PLANE/ PARLEL, PLAN1, ZSMALL, 0.5

PTN1 = PATTERN/ LINEAR, PT2, PT3, 4

PTN2 = PATTERN/ LINEAR, PT3, PT4, 3

PTN3 = PATTERN/ COPY, PTN2, UNLIKE, ON, PTN1



The Machining Plan

Point- to- point: refers to operations requiring fast movement (straight- line motions) to a point followed by a manufacturing operation at that point.

FROM/ <point location>: denotes that the point location is a starting point for the tool, with the end of the tool at that point.

GOTO/ <point location>: refers to a rapid, straight- line move to the point location indicated.

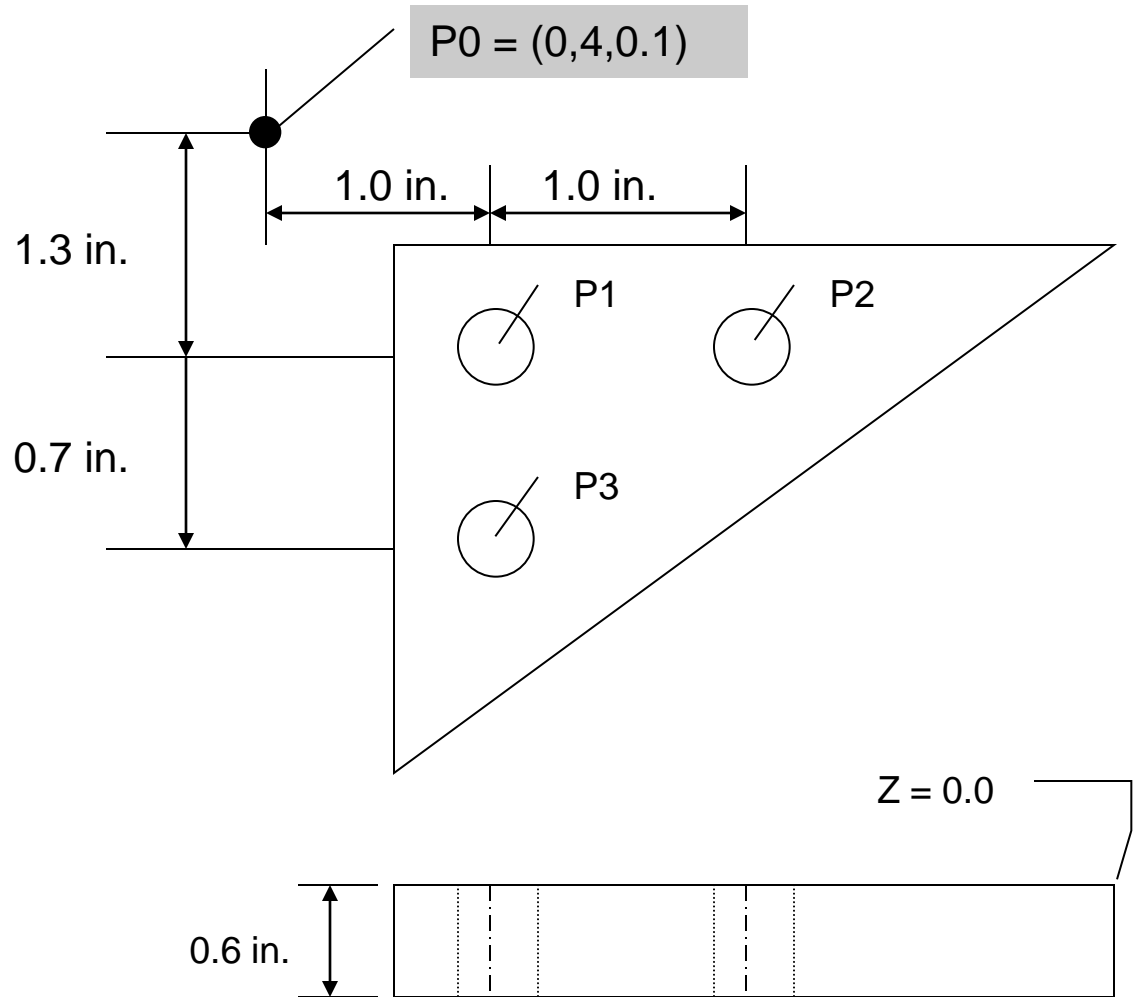
GODELTA/ <coordinate increments>: commands the tool to move incremental distance from the current position.

The Machining Plan

P1 = POINT/ 1.0, 2.7, 0.1

P2 = POINT/ 2.0, 2.7, 0.1

P3 = POINT/ 1.0, 2.0, 0.1



The Machining Plan

FROM/ P0

GOTO/ P1

GODELTA/ 0, 0, -0.8

GODELTA/ 0, 0, 0.8

GOTO/ P2

GODELTA/ 0, 0, -0.8

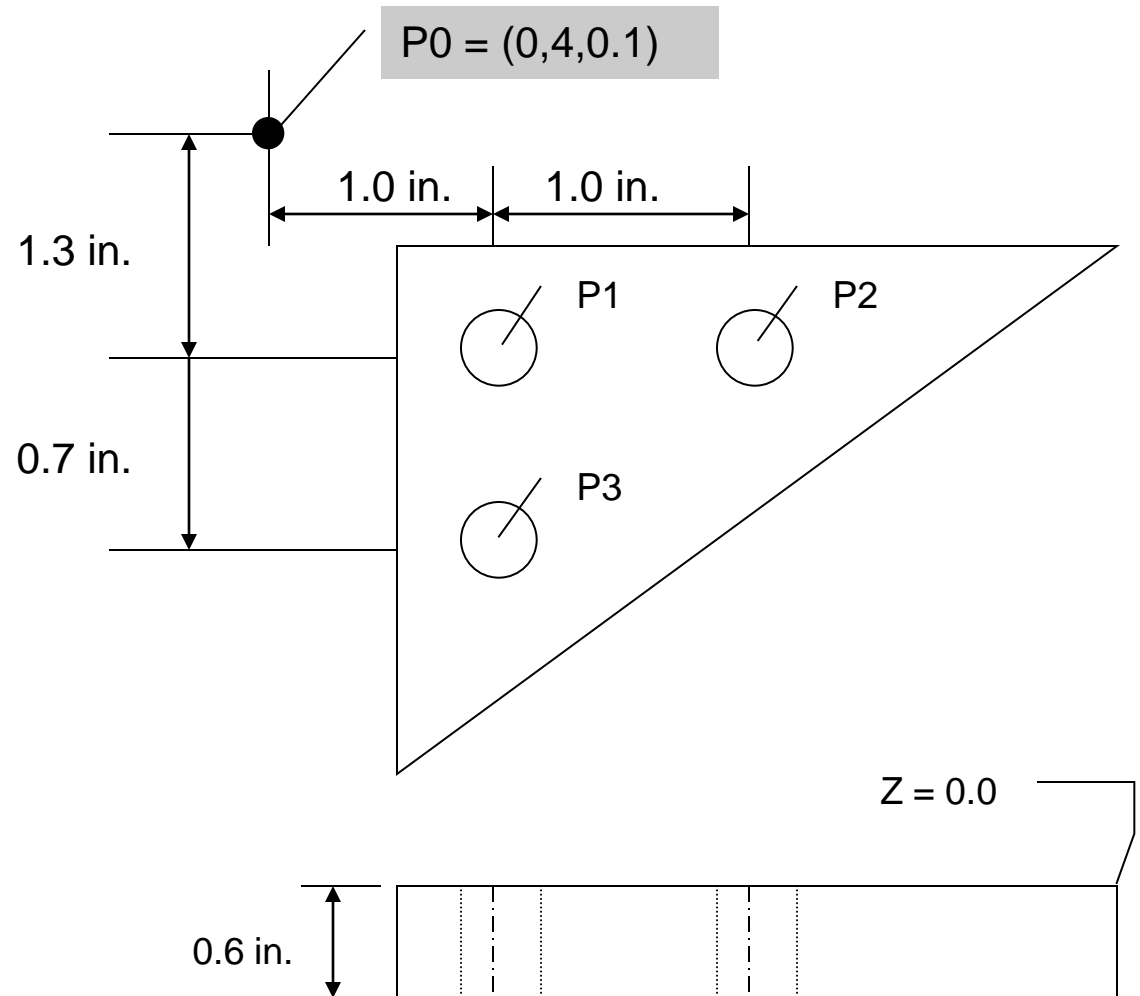
GODELTA/ 0, 0, 0.8

GOTO/ P3

GODELTA/ 0, 0, -0.8

GODELTA/ 0, 0, 0.8

GOTO/ P0



The Machining Plan

MACROS: A macro is a single computer instruction that stands for a given sequence of instructions.

<name> = MACRO/ <possible parameters><sequence of instructions>

TERMAC

The macro can be used any time in the APT program by

CALL macro name (, list of parameters)

The Machining Plan

PO = POINT/ 0, 4, 0.1

DELTA = MACRO/ DX, DY

GOTO/ DX, DY, _____

GODELTA/ _____, _____, _____

GODELTA/ _____, _____, _____

TERMAC

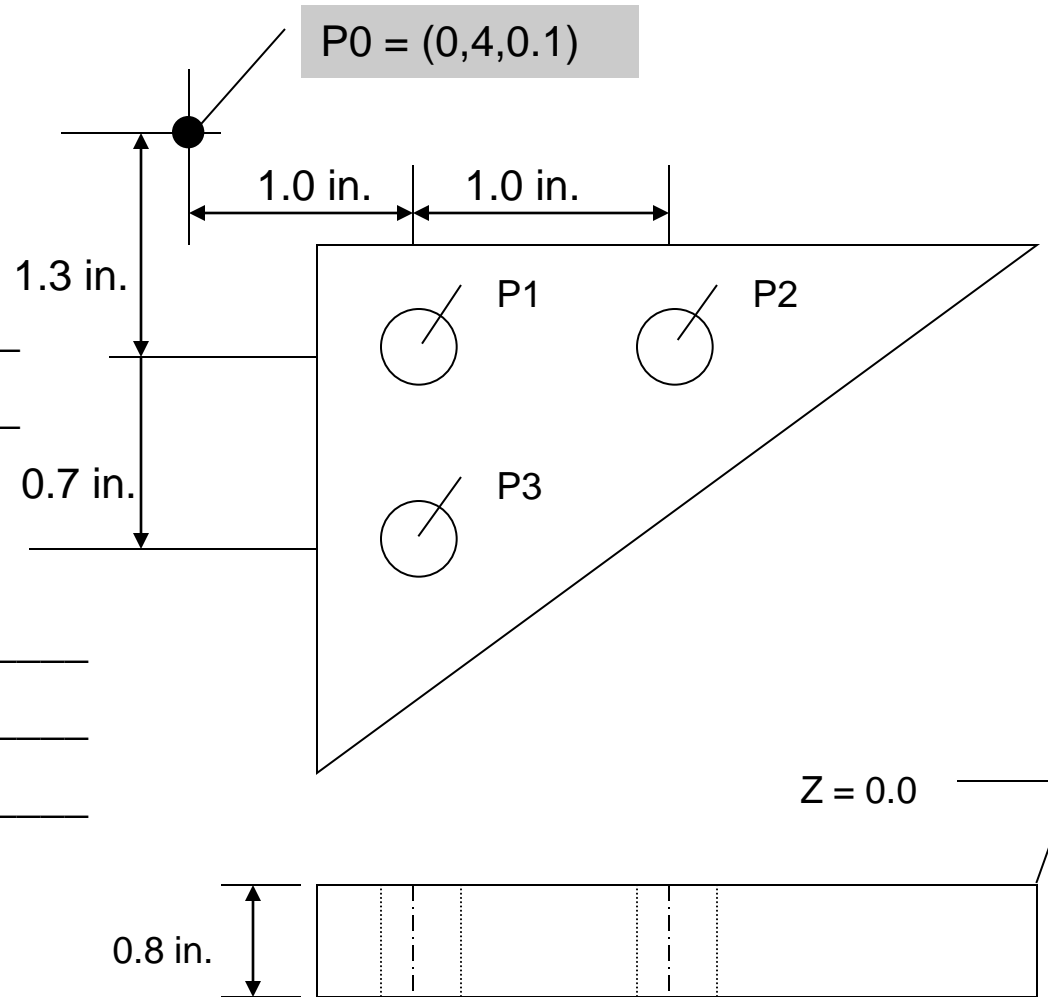
FROM/ PO

CALL DELTA/ DX = _____, DY = _____

CALL DELTA/ DX = _____, DY = _____

CALL DELTA/ DX = _____, DY = _____

GOTO/ PO



The Machining Plan:

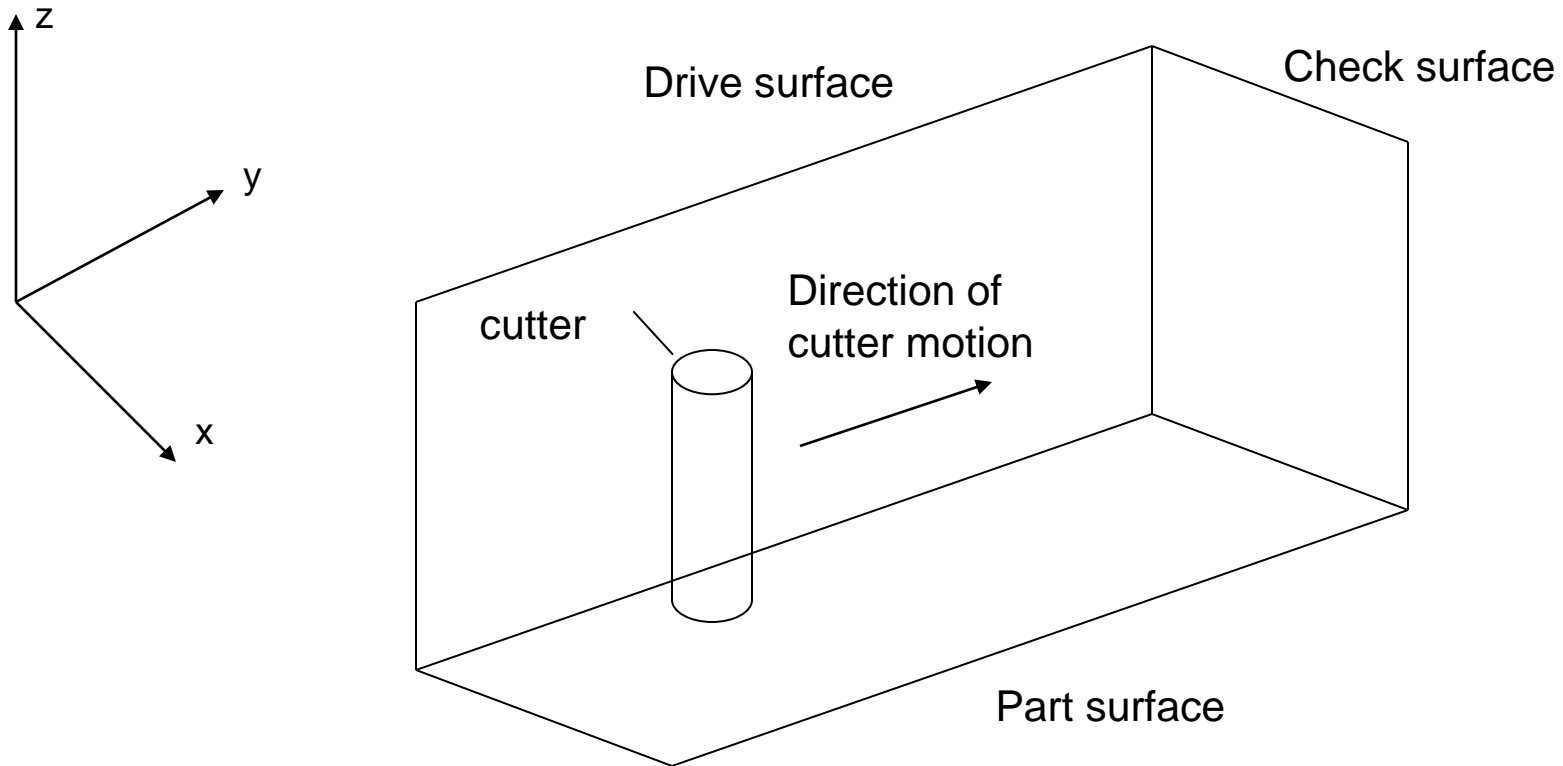
Contouring:

Part surface: the surface on which the end of the tool is riding.

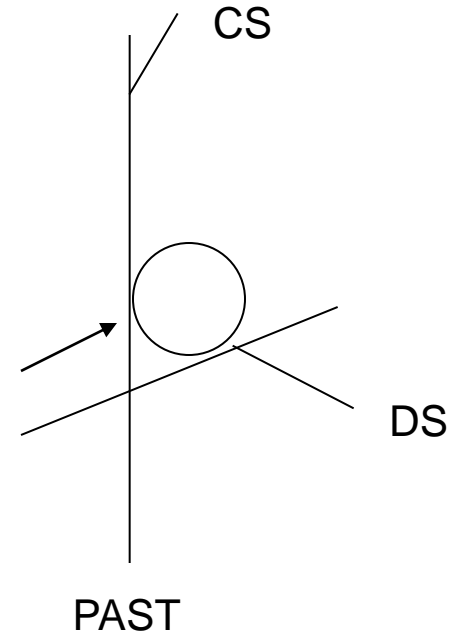
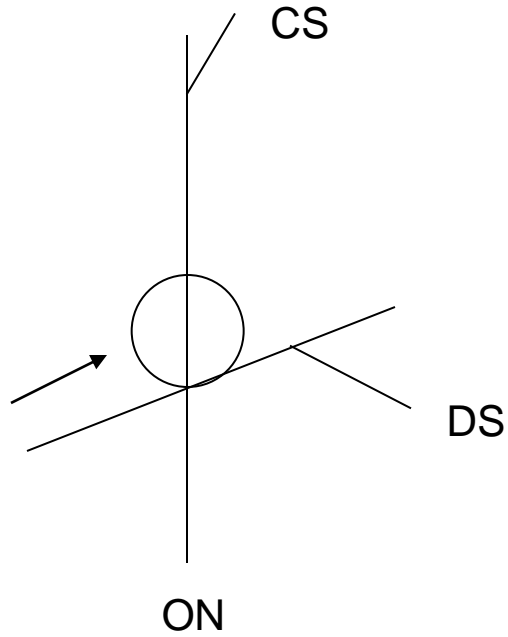
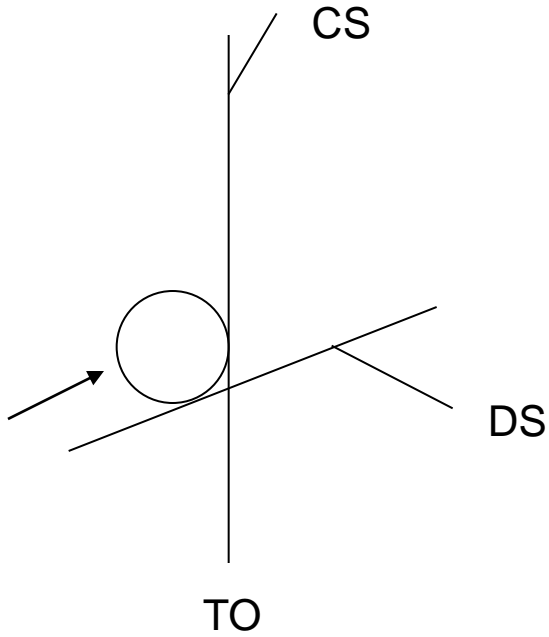
Drive surface: the surface against which the edge of the tool rides.

Check surface: a surface at which the current tool motion is to stop.

The Machining Plan



The Machining Plan

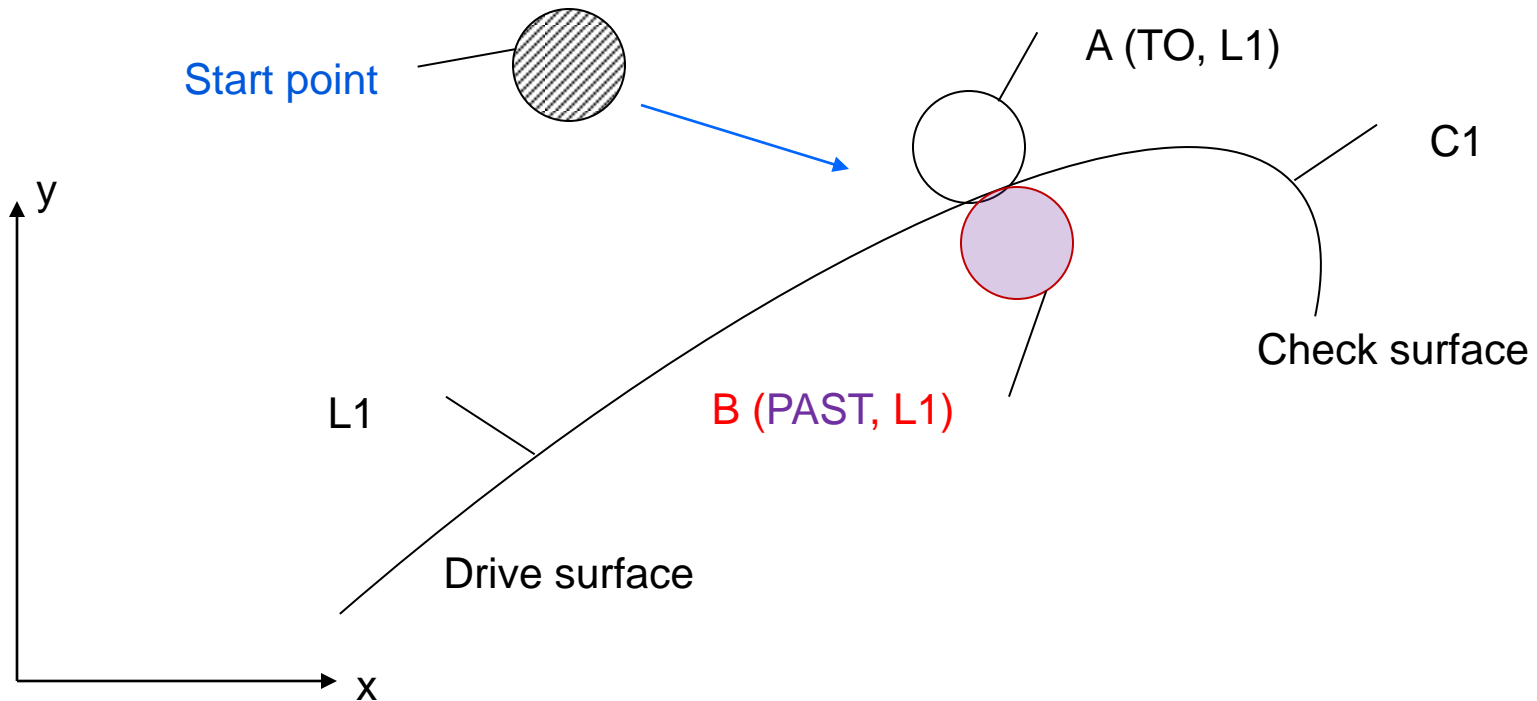


The Machining Plan

TANTO :

A: GO/ TO, L1, TO, PL2, TANTO, C1

B: GO/ PAST, L1, TO, PL2, TANTO, C1



The Machining Plan

Motion commands:

GOLFT/ : Move left along the drive surface

GORGT/ : Move right along the drive surface

GOUP/ : Move up along the drive surface

GODOWN/ : Move down along the drive surface

GOFWD/ : Move forward from a tangent position

GOBACK/ : Move backward from a tangent position

The Machining Plan

GORGT/ <drive surface>, <check surface>

Start → A → B → C → D → E → Start

FROM/ START

GO/ TO, L1, TO, PL1, ON, L3

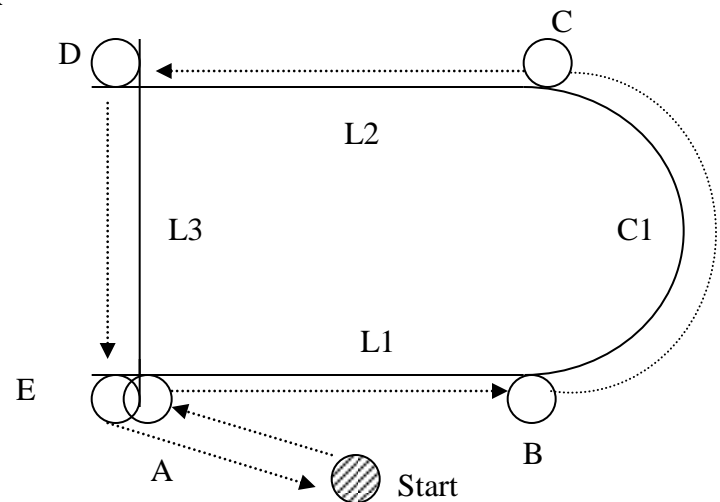
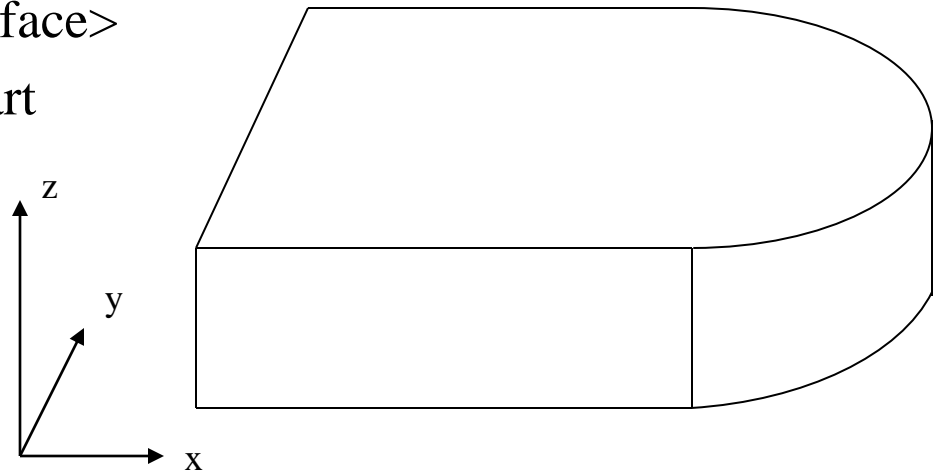
GORGT/ L1, TANTO, C1

GOFWD/ C1, TANTO, L2

GOFWD/ L2, PAST, L3

GOLFT/ L3, PAST, L1

GOTO/ START



Machining Specifications

Postprocessor commands for a particular machine tool are:

MACHIN/ : used to specify the machine tool and call the postprocessor for that tool:

MACHIN/ DRILL, 3

COOLNT/ : allows the coolant fluid to be turned on or off:

COOLNT/ MIST

COOLNT/ FLOOD

COOLNT/ OFF

Machining Specifications

FEDRAT/ : specifies the feed rate for moving the tool along the part surface in inches per minute:

FEDRAT/ 4.5

SPINDL/ : gives the spindle rotation speed in revolutions per minute:

SPINDL/ 850

TURRET/ : can be used to call a specific tool from an automatic tool changer:

TURRET/ 11

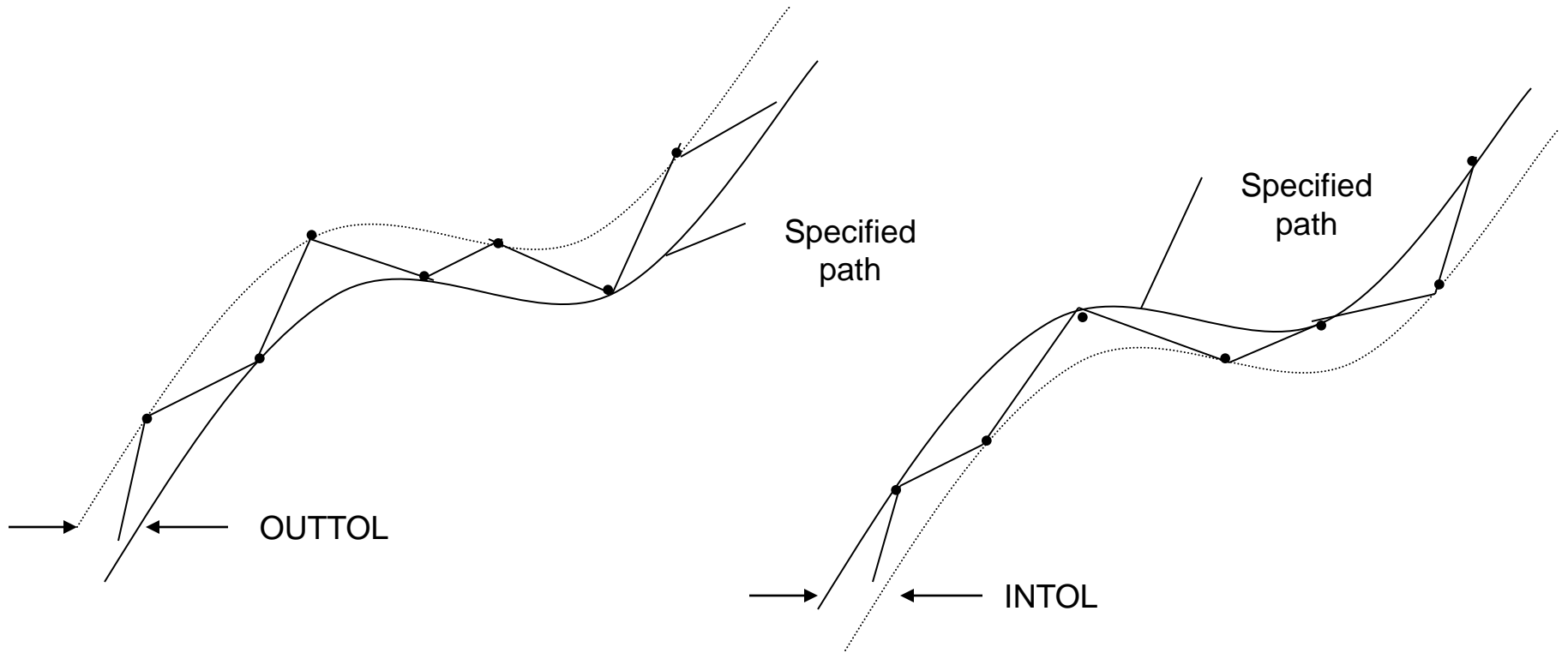
Machining Specifications

TOLERANCE SETTING: Nonlinear motion is accomplished in straight-line segments, and INTOL/ and OUTTOL/ statements dictate the number of straight-line segments to be generated.

INTOL/ 0.0015

OUTTOL/ 0.001

Machining Specifications



Machining Specifications

PARTNO: identifies the part program and is inserted at the start of the program.

CLPRINT: indicates that a cutter location printout is desired.

CUTTER: specifies a cutter diameter for offset (rough versus finish cutting). If a milling cutter is 0.5 in. in diameter and we have

CUTTER/ 0.6

then the tool will be offset from the finish cut by 0.05 in.

APT Contouring Example

PARTNO P1534

MACHIN/ MILL, 4

CLPRINT

OUTTOL/ 0.0015

P0 = POINT/ 0, 0, 1.1

P1 = POINT/ 1, 1, 0.5

P2 = POINT/ 4, 3.5, 0.5

P3 = POINT/ 5.85, 2.85, 0.5

PL1 = PLANE/ P1, P2, P3

PL2 = PLANE/ PARLEL, PL1, ZSMALL, 0.5

P4 = POINT/ 5, 1.85, 0.5

P5 = POINT/ 2, 2.5, 0.5

C1 = CIRCLE/ CENTER, P4, RADIUS, 0.85

C2 = CIRCLE/ CENTER, P5, RADIUS, 1.0

L1 = LINE/ P1, RIGHT, TANTO, C1

L2 = LINE/ P3, LEFT, TANTO, C1

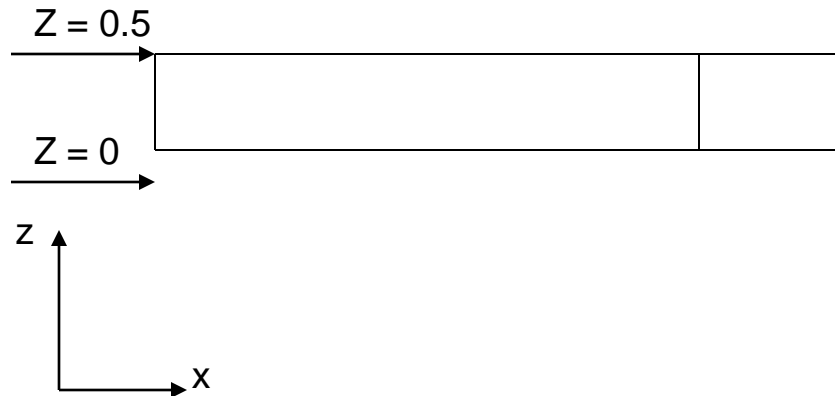
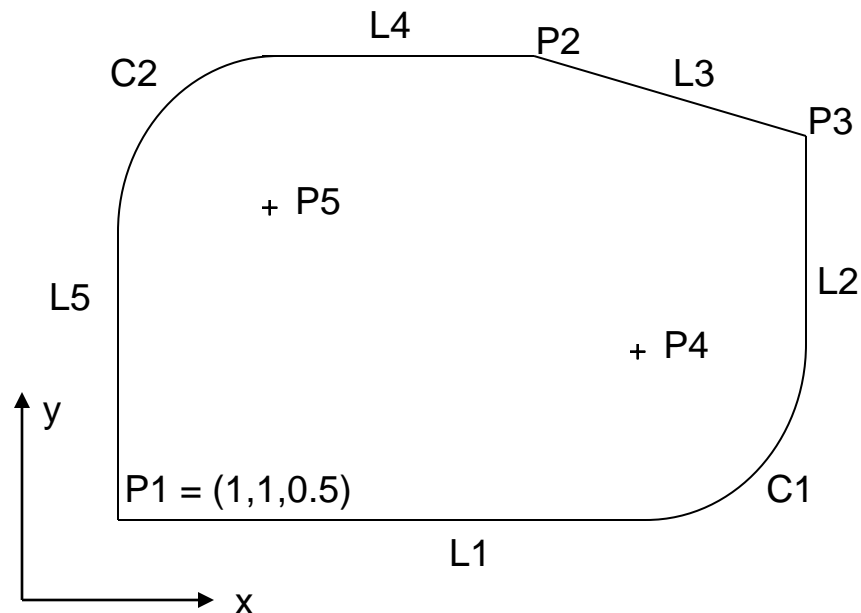
L3 = LINE/ P2, P3

L4 = LINE/ P2, RIGHT, TANTO, C2

L5 = LINE/ P1, LEFT, TANTO, C2

MILLS = MACRO/ CUT, SSP, FRT, CLT

CUTTER/ CUT



APT Program

P0 = POINT/ 0, -2, 0

P1 = POINT/ 0.312, 0.312, 0

P2 = POINT/ 4, 1, 0

C1 = CIRCLE/ CENTER, P1, RADIUS, 0.312

C2 = CIRCLE/ CENTER, P2, RADIUS, 1

L2 = LINE/ RIGHT, TANTO, C2, RIGHT, TANTO, C1

L1 = LINE/ LEFT, TANTO, C2, LEFT, TANTO, C1

PL1 = PLANE/ P0, P1, P2

FROM/ P0

GO/TO, L1, TO, PL1, TO, C2

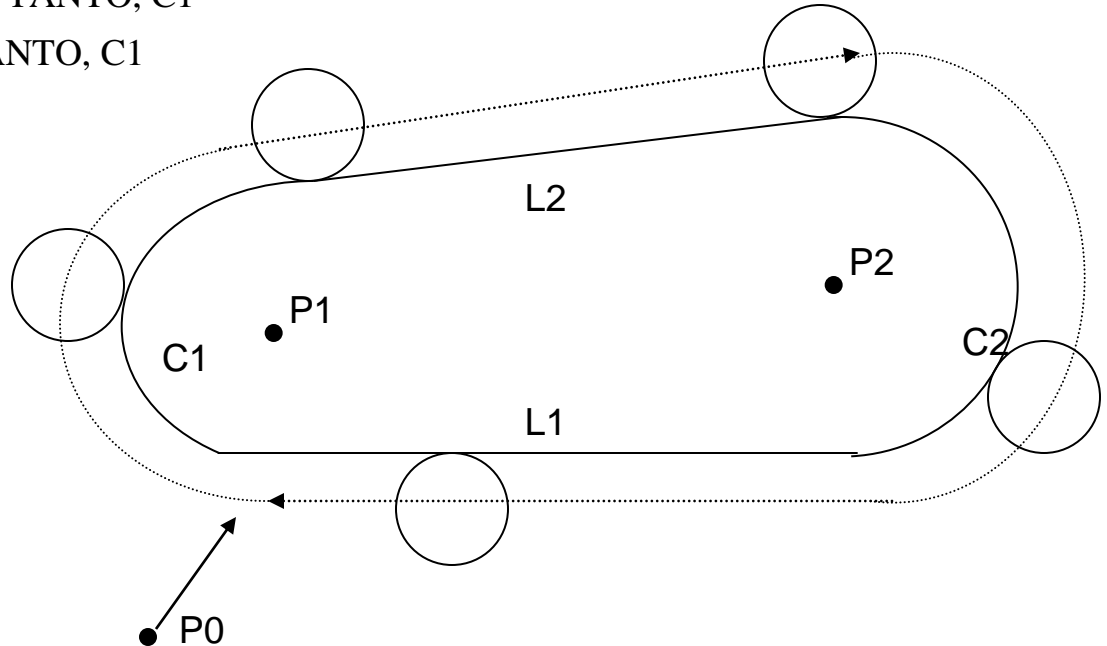
GOLFT/ L1, TANTO, C1

GOFWD/ C1, PAST, L2

GOFWD/ L2, TANTO, C2

GOFWD/ C2, PAST, L1

GOTO/ P0



Geometric Statements of APT Program

P0 = POINT/ -1, -1,3

P1 = POINT/ 0, 0

P2 = POINT/ 3, 0

P3 = POINT/ 4, 0

P4 = POINT/ 6.5, 5.5

C1 = CIRCLE/ CENTER, P3, RADIUS, 1

L0 = LINE/ P1, P2

L1 = LINE/ (POINT/ 5, 1), LEFT, TANTO, C1

L2 = LINE/ (POINT/ 7, 1), PERPTO, L1

C2 = CIRCLE/ CENTER, P4, RADIUS, 0.5

L3 = LINE/ (POINT/ 7, 1), RIGHT, TANTO, C2

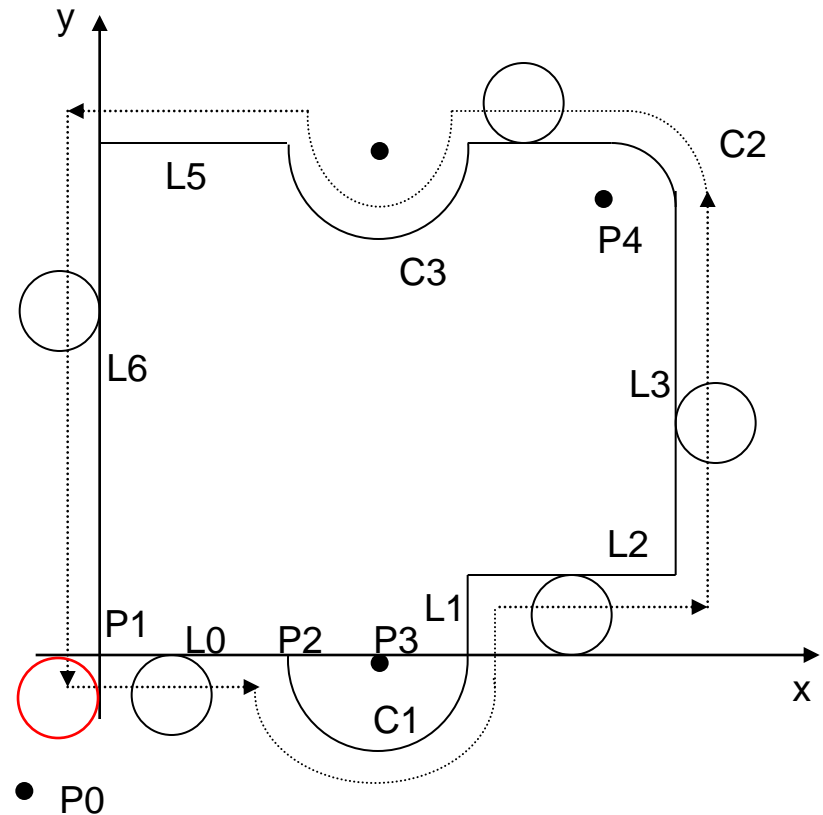
L4 = LINE/ (POINT/ 5, 6), LEFT, TANTO, C2

C3 = CIRCLE/ CENTER, (POINT/ 4, 6), (POINT/ 3, 6)

L5 = LINE/ (POINT/ 0, 6), (POINT/ 3, 6)

L6 = LINE/ P1, PERPTO, L5

PL1 = PLANE/ P1, P2, P3



Motion Statements of APT Program

FROM/ P0

GO/ TO, L0, TO, PL1, TO, L6

GODLTA/ 0,0,-1

GORGT/ L0, TO, C1

GORGT/ C1, TANTO, L1

GOFWD/ L1, TO, L2

GORGT/ L2, PAST, L3

GOLFT/ L3, TANTO, C2

GOFWD/ C2, TANTO, L4

GOFWD/ L4, PAST, C3

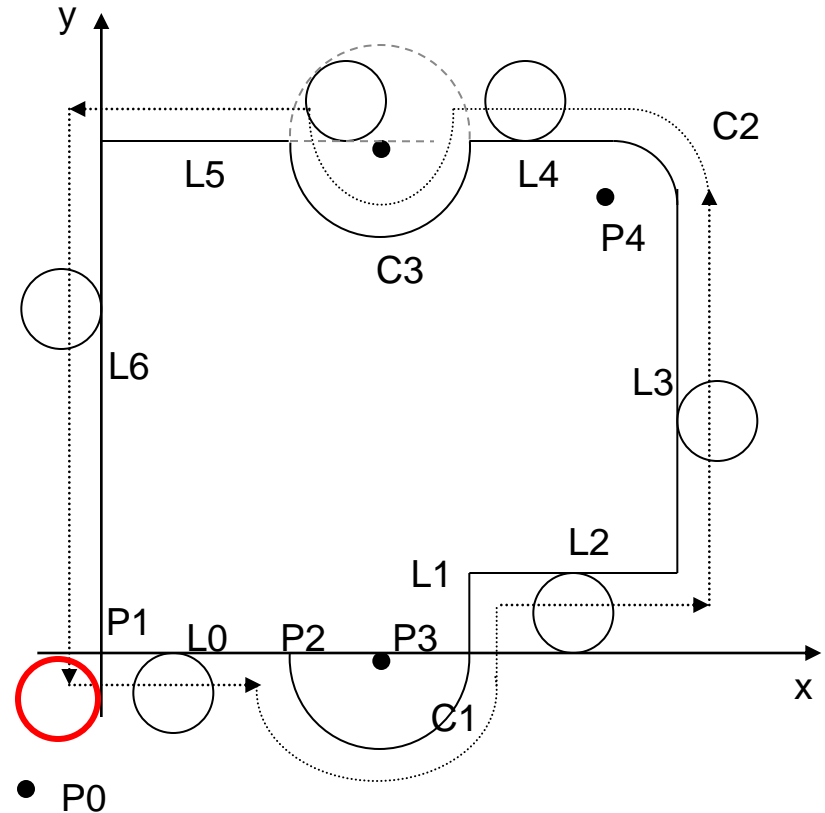
GOLFT/ C3, PAST, L5

GOLFT/ L5, PAST, L6

GOLFT/ L6, PAST, L0

GODLTA/ 0,0,1

GOTO/ P0



Thickness= 1 inch.

APT Program

MACHIN/ MILL

P0 = POINT/ 0, 0, 3

P1 = POINT/ 1, 0

L1 = LINE/ P1, SLOPE, 0

L2 = LINE/ P1, SLOPE, 90

L3 = LINE/ PARLEL, L1, YLARGE, 2

L4 = LINE/ (POINT/ 4, 2), SLOPE, 1, L3

L5 = LINE/ (POINT/ 6, 4), ATANGL, 270, L4

L6 = LINE/ (POINT/ 10, 0), PEPTO, L3

P2 = POINT/ INTOF, L3, L4

P3 = POINT/ INTOF, L4, L5

P4 = POINT/ INTOF, L5, L3

PL = PLANE/ P1, P2, P3

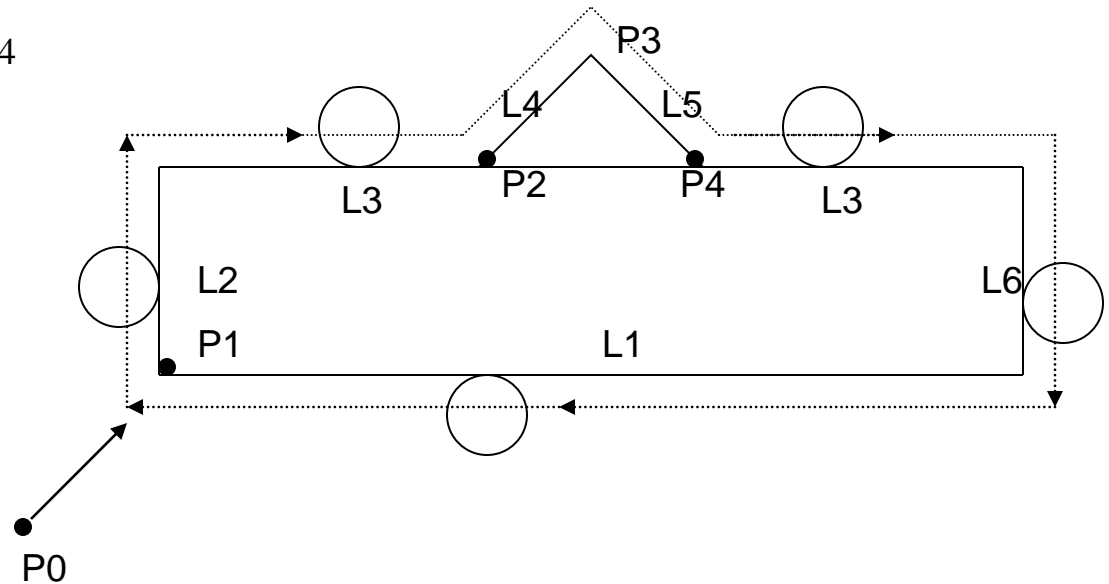
CUTTER/ 60

TOLER/ 0.1

SPINDL/ 200

COOLNT/ ON

FEDRAT/ 20



APT Program

FROM/ P0

GOTO/ L1, TO, PL, TO, L2