

Experiment No. 4

**STUDY OF DCC-COORDINATE MEASURING MACHINE AND EXPLORING FEW
DIMENSIONAL FEATURES OF AN ARTEFACT**

Aim:

- To study the functions of different parts of CMM.
- To study the conventions used for Machine Coordinate System and Workpiece Coordinate System.
- To calibrate the probe tip at three different angles.
- To check different dimensional attributes like circularity, cylindricity, flatness, run out, etc and the corresponding tolerance values.

Principle of measurement:

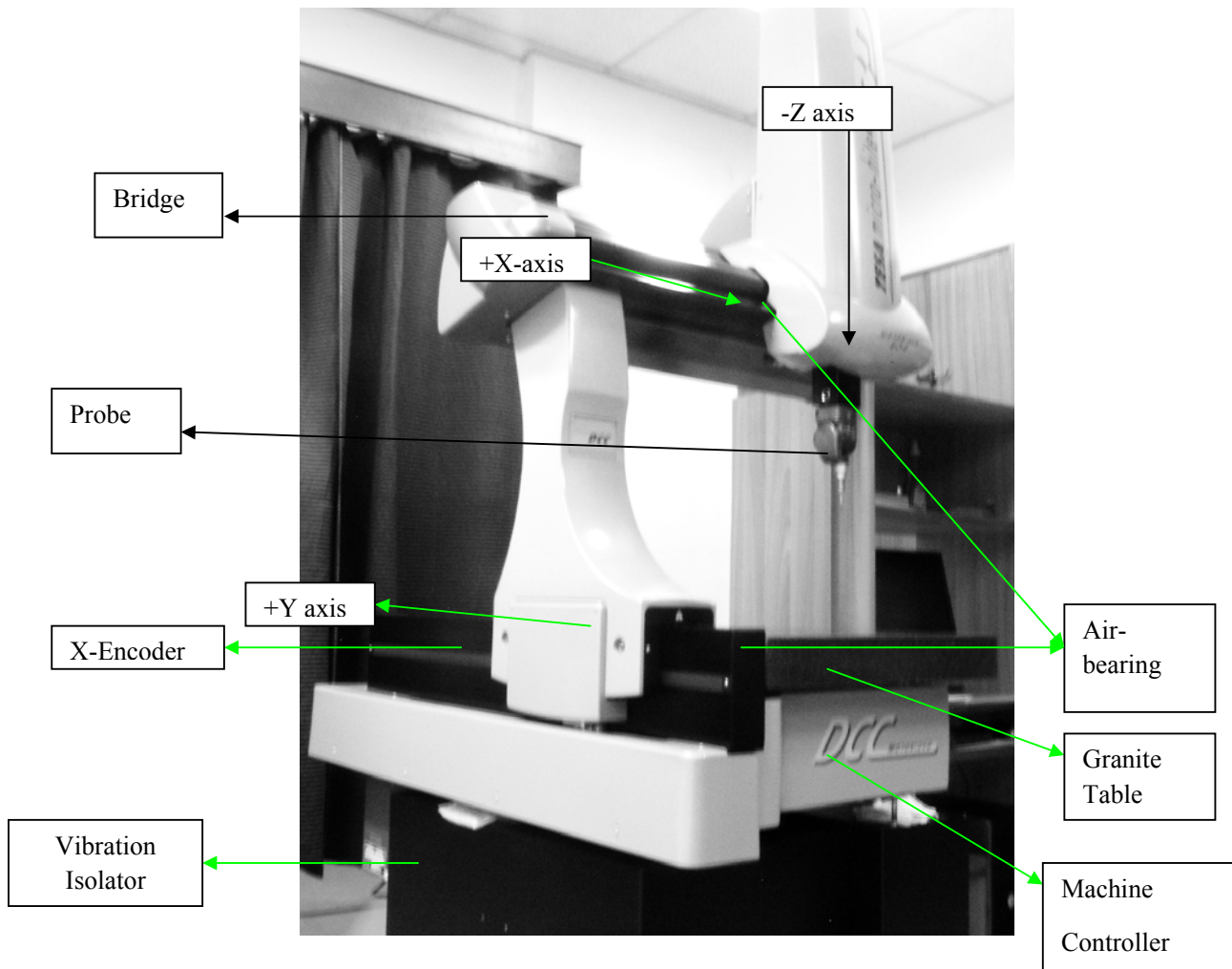


Fig 1 Co-ordinate Measuring Machine with its parts

It is used for **geometrical feature measurement**. The typical "bridge" CMM is composed of three axes, **X, Y and Z**. These axes are orthogonal to each other in a typical three dimensional coordinate system. Each axis has a **scale system or encoder** that indicates the translation of the axes. The machine will read the input points from the touch probe by touching the required location, as directed by the operator or programmer. The machine then uses the X,Y,Z coordinates of each of these points to determine size and position of the job. Then the measurands (e.g. length, diameter, angle, flatness, straightness etc.) can be determined by those points. A coordinate measuring machine (CMM) is also a device used in manufacturing and assembly processes to test a part or assembly against the design intent. By precisely recording the X, Y, and Z coordinates of the target, points are generated which can then be analyzed via **regression algorithms** for the **construction of features**. These points are collected by using a probe that is positioned manually by an operator or automatically via **Direct Computer Control (DCC)**. **DCC CMMs** can be programmed to repeatedly measure identical parts; thus a CMM is a specialized form of [industrial robot](#). In CMM there are mainly two major parts. There are **structural system** and **probing system**. Machine structure, bridge, bearings for moving the bridge, granit table to support the workpiece, vibration isolation system and are included in the structural systems. Air bearings are the chosen method for ensuring friction free travel. Compressed air is forced through a series of very small holes in a flat bearing surface to provide a smooth but controlled air cushion on which the CMM can move in a frictionless manner. In probing system one touch trigger probe is attached to the Z-axis quill of the bridge.

When probe is rotated about X-axis it is then called as angle **A**, and when the probe is rotated about Z-axis, then it is called as angle **B**.

Tesastar-p is the probe used in this machine. This probe can rotate in two directions viz **A & B**

A0B0:- Angle A=0, and Angle B=0

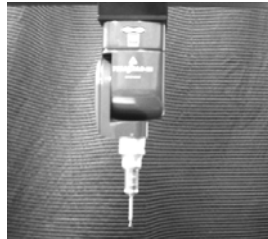


Fig 2a A0B0 position of probe

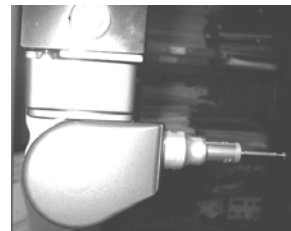


Fig 2b A90B90 position of probe

When rotation of probe is in CCW manner w.r.t. axis of rotation than it is considered positive else negative.

Range of angles:

Angle A: Probe can rotate from +90 to -115 about X-axis.

Angle B: Probe can rotate from +180 to -180 about Z- axis.

Measuring Modes: Manual Mode and Automatic Mode .

Jobs to do:

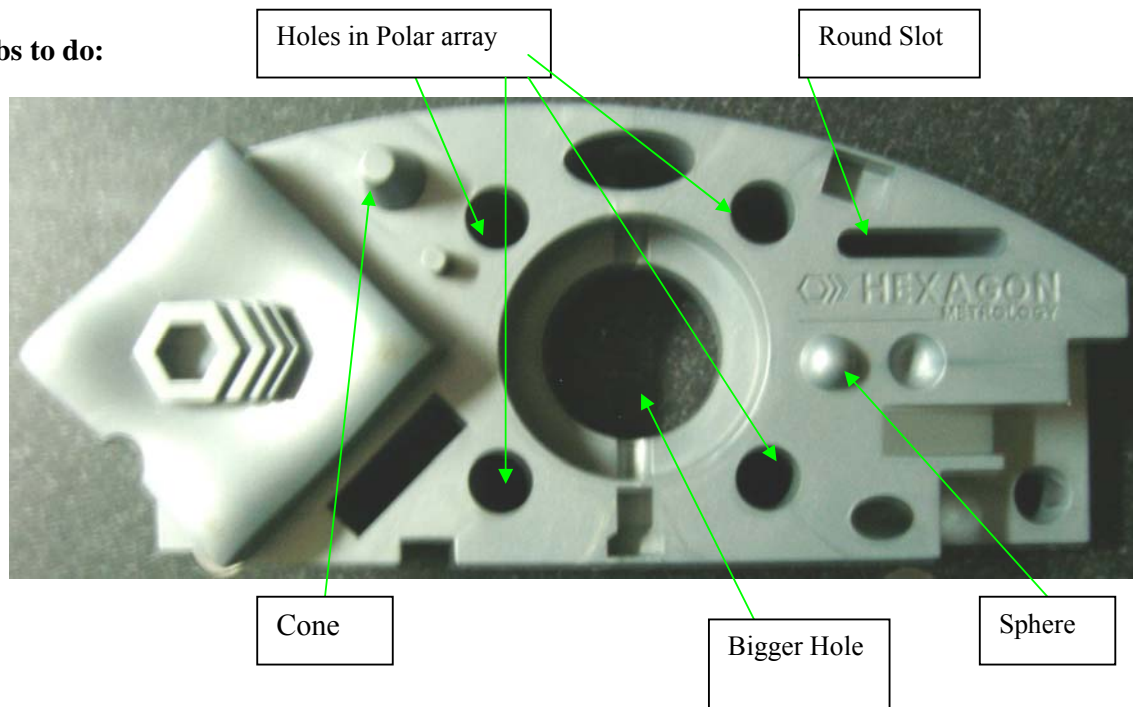


Fig 3 Job 1 (Artefact supplied by TESA)

Job 1: Artefact supplied by TESA

1. Define plane, line and origin in manual mode.
2. Measure:
 - a. Inner diameter, circularity of the Bigger Hole
 - b. Height, cone angle and diameter of the Cone
 - c. Round slot
 - d. Measurement of all the holes in polar array in DCC mode
 - e. Sphere diameter

Feature	Dimension	1	2	3	Avg Value, mm
Bigger Hole	Inner diameter				
	Circularity				
Cone	Height				
	Cone angle				
	Diameter				
Round slot	Radius				
Holes in polar array	Diameter				
Sphere	Diameter				

Job 2: Spur Gear

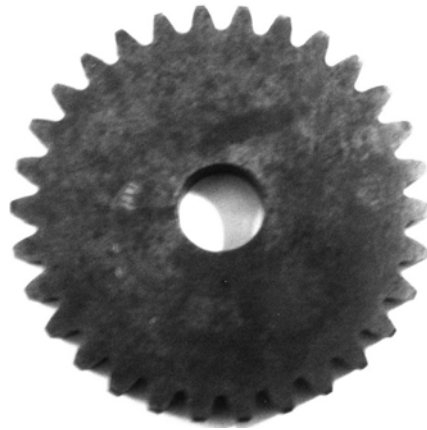
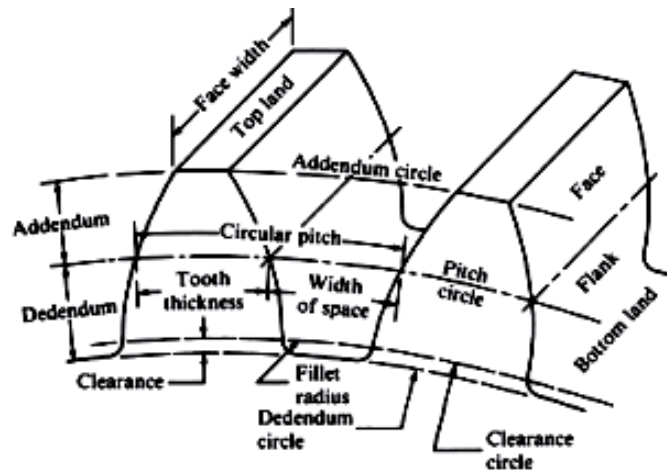


Fig 4 Job 2 (Spur Gear)



Dimension	1	2	3	Avg Value, mm
Addendum circle diameter				
Root circle diameter				
Pitch				

Specifications of CMM and probe used:

Sl No	Items	Specifications
1	Bridge type CMM	Measuring Volume: 400 mm x 700 mm x 400 mm. TESA (Swiss Company): Model 4-7-4 Resolution: 0.1 μ m
2	Qualification Sphere	Motorized Probing System Material of probe tip: Ruby Diameter of probe tip: 1/2/4 mm

Report Should Contain:

- a. A neat sketch of CMM with proper mentioning of the machine and probe axes.
- b. Calibration procedure of probe tip at angles: A__B__, A__B__ and A__B__ and show results.
- c. Comment on variation of the standard deviation errors (if any) in previous results.
- d. Check dimensional attributes and tolerances for the job provided.
- e. Comment on why a sphere has been chosen for the tip.
- f. What is the material for probe tip and why is it chosen?
- g. Why is it better to use a bigger diameter tip for measurement?
- h. What is the principle of slide-guide mechanism for all the three machine axes?

Precautions:

! Never touch the granite base on the machine for accuracy issues.

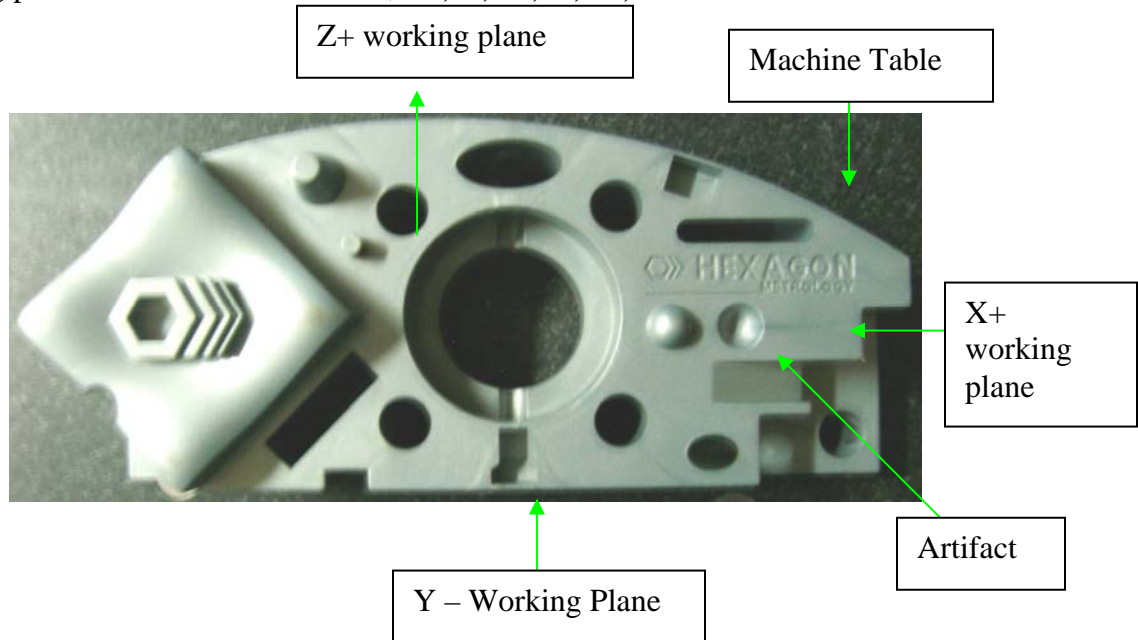
! Do not touch the Axis slides, probe head/tip, and the guides.

Calibration and Measurement procedures are detailed in
ANNEXURE - I

ANNEXURE 1

Description of Working Plane:

There are 6 working plane in this machine such as, **Z+,Z-,Y+,Y-,X+,X-**.



Note: Z- will be in opposite direction of Z+ plane. Similarly, X- & Y+ will be in opposite directions of X+ and Y- planes, respectively.

Orientation Concept of Probe:

When probe is rotated about X-axis it is then called as angle **A** and when probe is rotated about Z-axis, then it is called as angle **B**.

Tesastar-p is the probe used in this machine. This probe can rotate in two directions viz **A & B**

A0B0:- Angle A=0, and Angle B=0



A0B0 position of probe



A90B90 position of probe

Convention:

When rotation of probe is in CCW manner w.r.t. axis of rotation than it is considered positive else negative.

Range of angles:

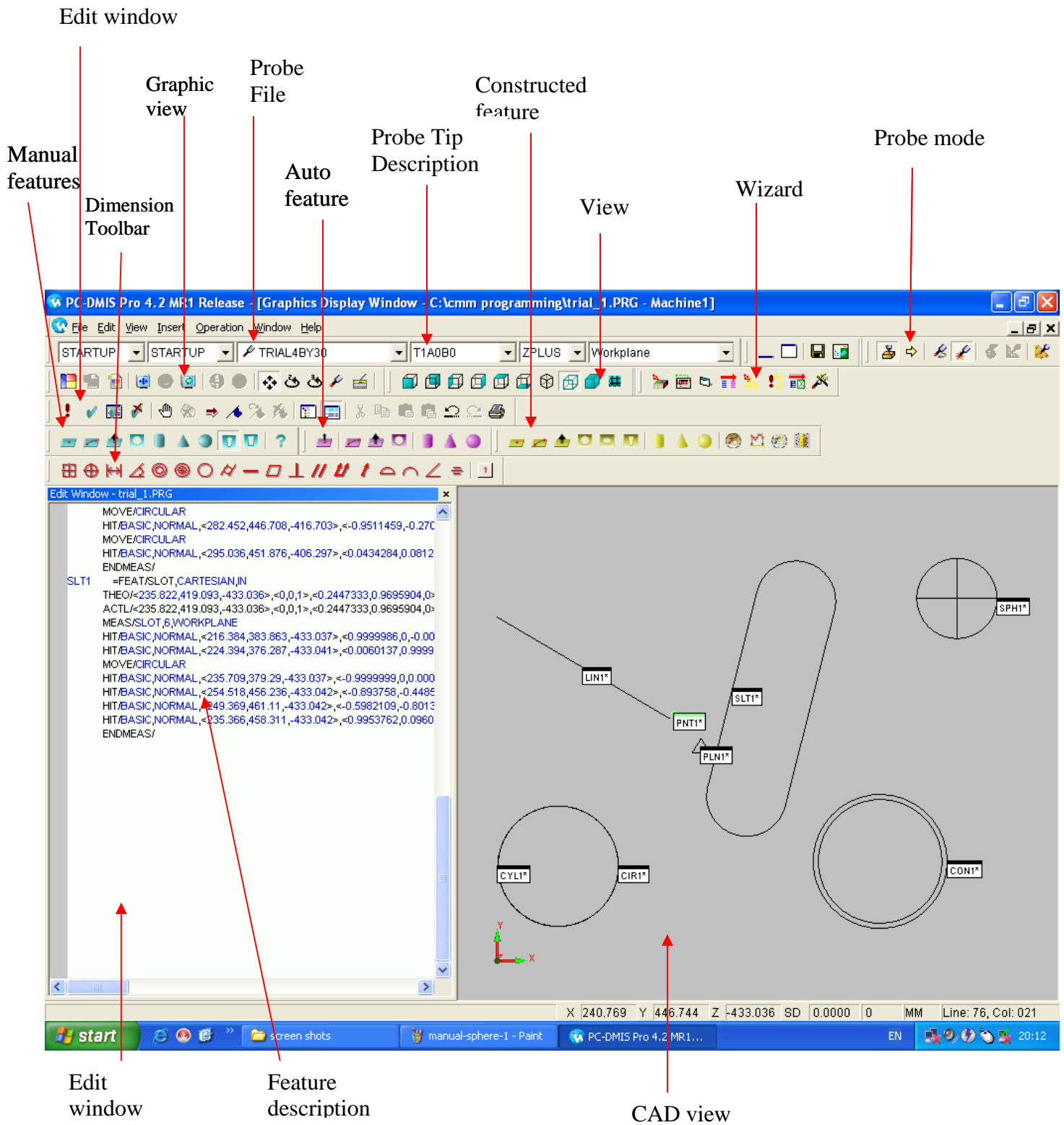
Angle A: Probe can rotate from +90 to -115 about X-axis.

Angle B: Probe can rotate from +180 to -180 about Z- axis

Description of Remote Control Unit:



Description of Graphics Display Window:



Probe Calibration:

Probe calibration is important while creating a new Part Program

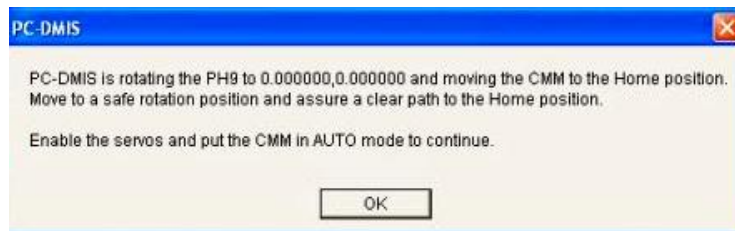
1. Open the PCDMIS program by double clicking on the **Online** desktop icon. Otherwise PCDMIS can also be opened by selecting the **Start>All Programs > PCDMIS for Window>Online**.



2. Select a Probe file. Recently used probe file will be shown. If new tip is going to be attached, select **Probe File**, otherwise select already displayed one.



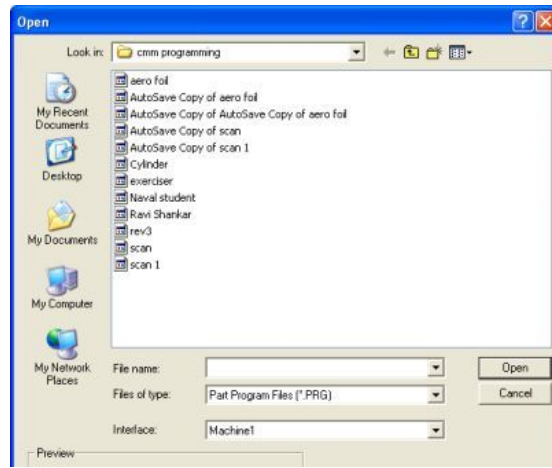
3. At this stage the system will prompt for homing. **First make sure to clear the work table for safe movement of the probe.** Select **OK** to permit the machine to go in home position.



4. Following message will appear if the remote is not set in Auto mode. Click the **AUTO** button on remote control.

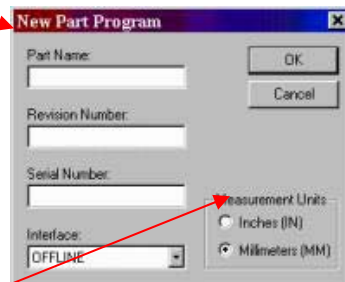


5. Once machine comes to homing position, place the **Qualification Sphere** in the middle of the work table. The **Open File** dialog box will appear on the screen. If you have previously created a part program, you can load it from this dialog.



6. Since you are creating a new part program, select the **Cancel** button to close the dialog box.

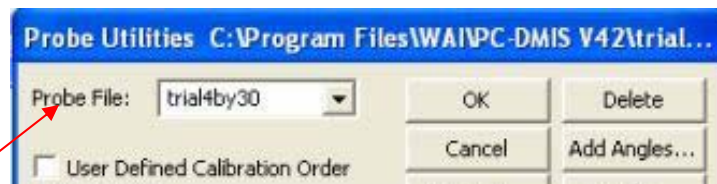
7. Go to **File>New> New Part Program** box. In the **Part Name** box, type **Filename**. If the **Interface** shows **OFFLINE** it means machine is not connected.



8. Select the **Measurement Units** option for the measurement.

As soon as you have created a new part program, PCDMIS will open the main user interface and then immediately open the **Probe Utilities** dialog box for you to load a probe.

*The **Probe Utilities** dialog box, can also be accessed by selecting **Insert > Hardware Definition > Probe**, allows you to define a new probe. When you first create a new part program, PCDMIS automatically brings up this dialog box.*



Probe Utilities dialog box

9. In the **Probe File** box, type the already created **Part Name** as the name of the probe file. Later, when you create other part programs, your probes will be available in this dialog box for selection.

10. Select the statement: No Probe defined.

The **Probe Description** area of the **Probe Utilities** dialog box allows you to define the probe, extensions and tip (s) that will be used in the part program. The **Probe Description** dropdown list displays the available probe options in alphabetical order.

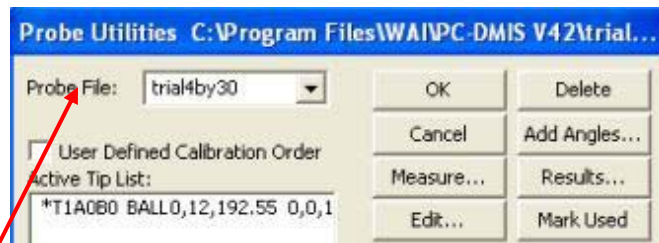
Select your probe using the **Probe Description** combo box:



11. Select the line "Empty Connection #1" and continue to select the necessary probe parts until your probe is built.

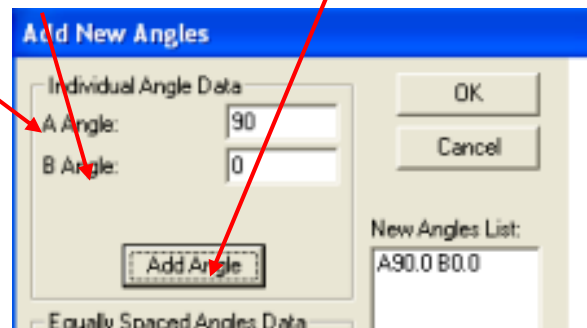
- Select: TESASTAR-M (selected by default) (Probe Head)
- Select: TESA-TMA (Probe Connector)
- Select: TESASTAR-P (Probe)
- Select: Tip-(dia.) by (Length) mm (Stylus)

** For example, if we are using 4 mm diameter probe tip having 30 mm stylus length then select: Tip4BY30MM (Stylus)

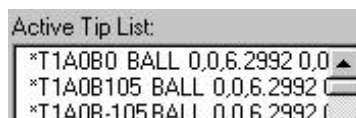


Verify that the defined **Probe File** is displayed in Probe Window; else select from the drop down menu.

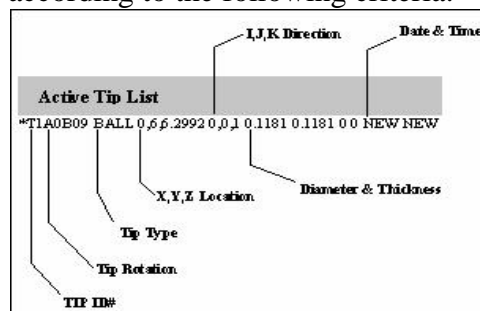
13. Click Add Angles... from probe utilities window to select probe angle. Fill up the required probe angles against the box A Angle and B Angle, then click Add Angle > OK.



Active Tip List



PCDMIS describes a probe according to the following criteria:



Tip ID

This is the permanent number that PCDMIS assigns to a tip when it is loaded into memory.

Tip Rotation

This field displays the rotation of the tip in the vertical (A) and horizontal (B) direction

Tip Type

This field displays the probe type (BALL, DISK, TAPER, SHANK, OPTICAL).

XYZ Nominal

These values describe the location of the tip. This location is in relation to the bottom of the Z rail.

IJK Direction

These values describe the direction of the probe tip. This vector goes from the center of the probe tip towards the Z rail.

Diameter and Thickness

These values describe the diameter of the tip and the thickness of SHANK and DISK probes. PCDMIS defines these values when the probe is loaded.

Calibration Date and Time

These boxes indicate the most recent date and time the probe tip was calibrated. If a new tip is created without being calibrated, PCDMIS will display NEW for the date and time values. If an old probe tip is loaded and the date and time information is unavailable, PCDMIS will display UNKNOWN for the values. Only probe tips that are actually calibrated have their time and date values updated.

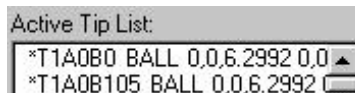
Only one tip may be edited at a time.

Non-calibrated Tip

An asterisk (*) identifies any non calibrated tips.

The Edit window command line for a sample tip would read:

TIP/T1A0B0, SHANKIJK=0, 0, 1, ANGLE=0



Non calibrated Tips Marked with Asterisks ()*

14. Select *A0B0 unmarked probe feature and click **Measure** from **Probe Utilities** window. **Measure Probe** window will appear

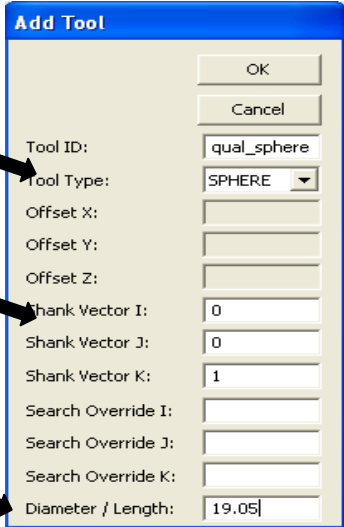
Select **Man+DCC** option when calibrating the first position of probe (i.e. A0B0). Select **DCC+DCC** for subsequent angles.

Default Mode: The machine decides on its own the number of levels. The equator is considered to be at 0 degree start angle and the poles at 90 degree when the tip moves vertically down.

Add Tool: Specify the specification of the qualification tool

By Clicking **Add Tool...** following window will appear

Fill the boxes as shown in the window.



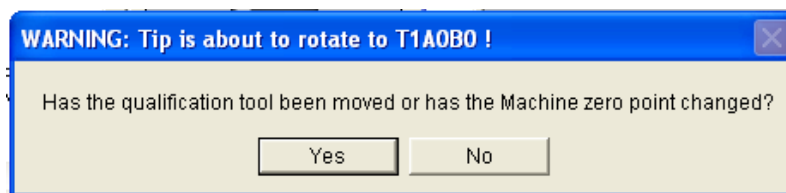
The 'Add Tool' dialog box contains the following fields and values:

Field	Value
Tool ID:	qual_sphere
Tool Type:	SPHERE
Offset X:	
Offset Y:	
Offset Z:	
Shank Vector I:	0
Shank Vector J:	0
Shank Vector K:	1
Search Override I:	
Search Override J:	
Search Override K:	
Diameter / Length:	19.05

Once you define a new tool, it will appear in the **List of Available Tools** dropdown list located in the **Measure Probe** dialog box.

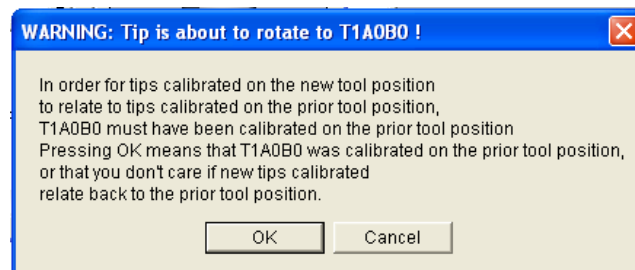
At least one probe tip must be defined in the Active Tip List before measuring a tool.

16. After setting Tool type, click **OK** and click **Measure** in the **Measure Probe** window, the following warning message will pop up:

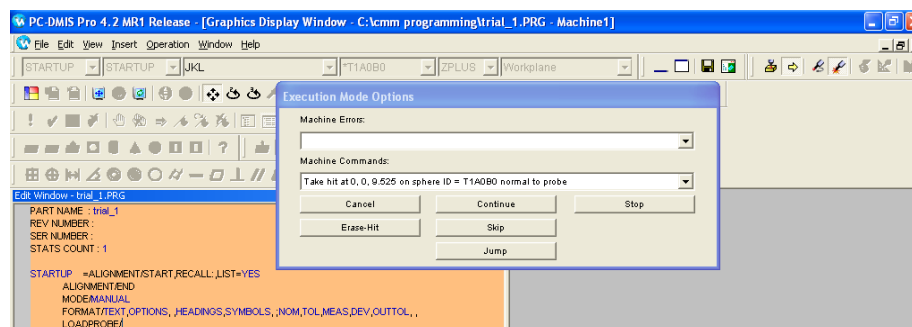


If the qualification tool has been moved from the previous position select **Yes**, otherwise **No**.

On selecting **Yes** a final confirmation window for calibration will come up:

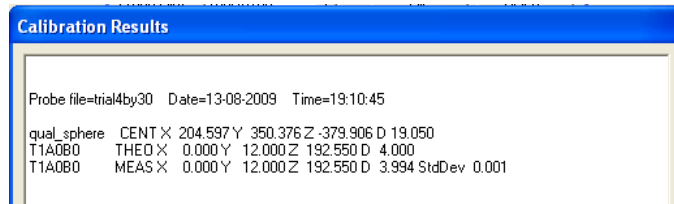


17. Once we click **OK** the execution window will begin for the manual hit on approximately top of the **Qualification Sphere** as cited below:



Press **SLOW** button on **REMOTE CONTROL UNIT** and take one hit manually on the top of the sphere and press **RTN TO SCREEN**. Press **AUTO** on the remote control as command **AUTO MODE REQUIRED** appears at the bottom of the display window.

18. Calibration Results: Coming back to **Probe Utilities Window** click **Results** and check the standard deviation value. Assure the Std. Dev value lies within 0.008 mm, otherwise stop the machine and go for tightening the extension-stylus-tip joints.

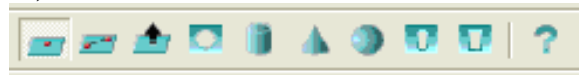


Click **OK**.

To calibrate rest of the angles (if any), change **Man+DCC** to **DCC+DCC** in the **Measure Probe** window to repeat the above procedure.

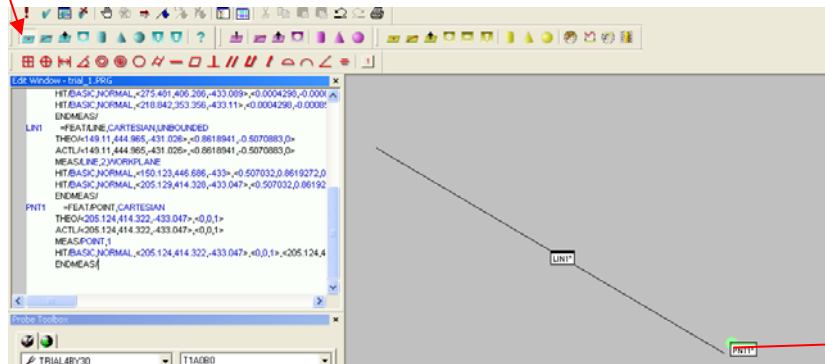
19. Once calibration is over, remove the **Qualification Sphere** and place the job on the work table

Creating Features (Manual mode): Preamble: Manual+DCC



a. Create a Point ()

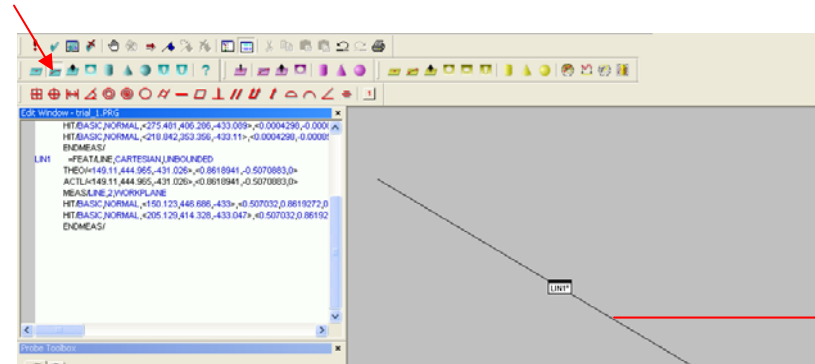
Click on **Measured Point** icon. Take a hit on the surface (where point is to be made) > **RTN TO SCREEN** from remote control



Point 1

b. Create a Line ()

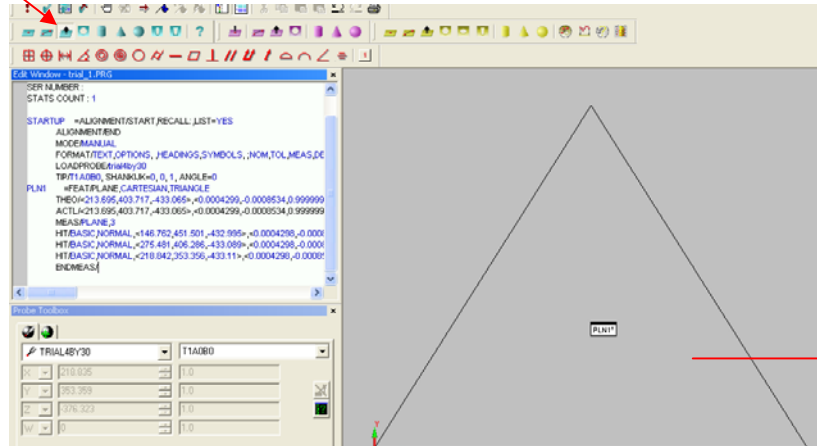
Click on icon **Measured Line** > Take two points on a surface > Press **RTN TO SCREEN**.



Line1

c. Create a Plane ()

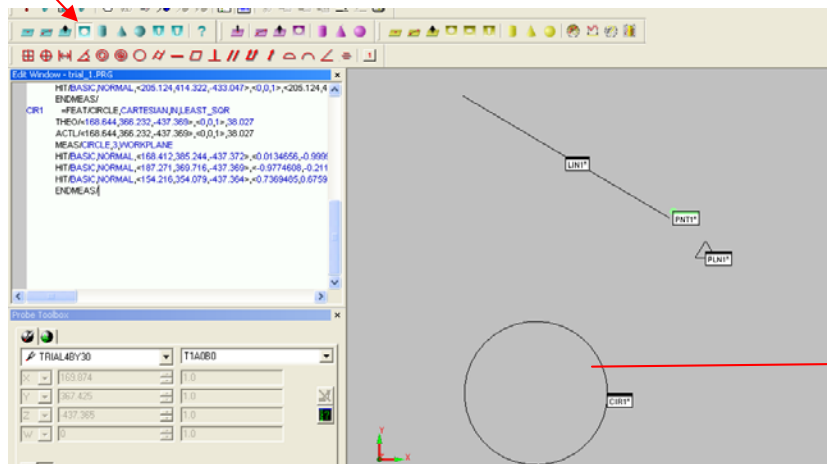
Click on **Measured Plane** icon > Take three points such that it covers the entire plane> **RTN TO SCREEN**. -



Plane 1

d. Creating a Circle()

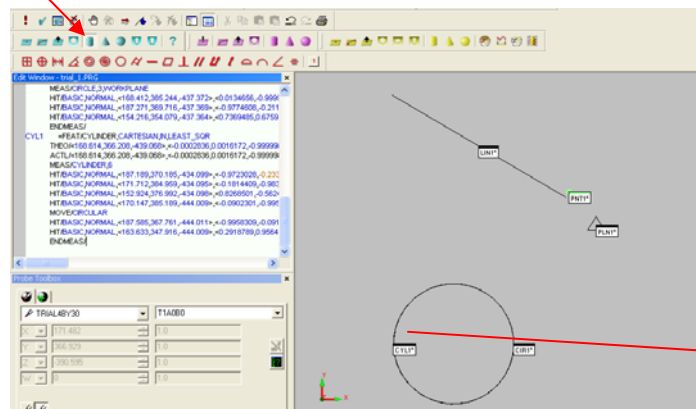
Click on **Measured Circle** icon>Take three hits on the inner periphery of circle (in CW or CCW manner)> Press **RTN TO SCREEN**.



Circle 1

e. Create a Cylinder ()

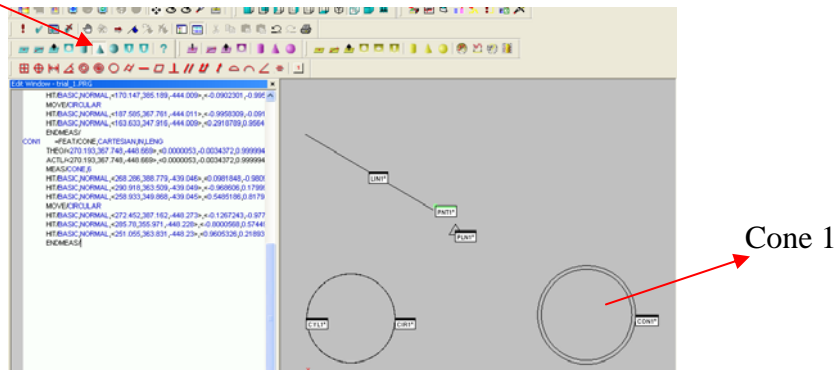
Click on **Measured Cylinder** icon> Take 3 hits on top inner periphery of cylinder> take 3 hits at the approx. bottom periphery (inner) of cylinder (use CW or CCW manner for both type of hits) > Press **RTN TO SCREEN**.



Cylinder1

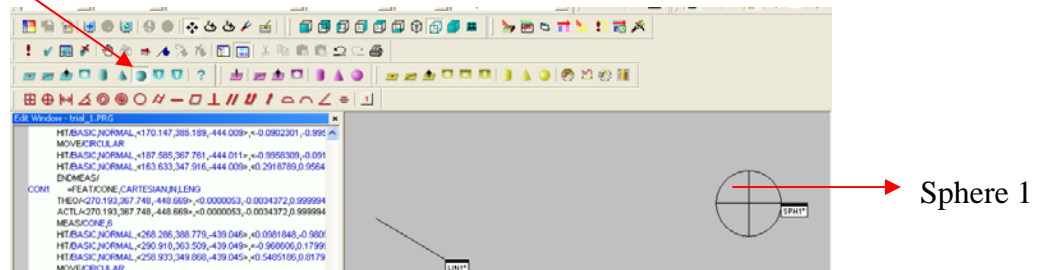
f. Create a Cone ()

Click on **Measured Cone** icon> Take 3 hits on top inner periphery of cone> take 3 hits at the approx. bottom of the periphery (inner) of cone (use CW or CCW manner for both type of hits) > Press **RTN TO SCREEN**.



g. Create a Sphere ()

Click on **Measured Sphere** icon> Take 3 hits on the equatorial plane > Take 1 hit at approx. top > Press **RTN TO SCREEN**



h. Create a Round Slot ()

Click **Measured Round Slot** > Take 3 hits on inner periphery of semicircle> Take 3 hits on inner periphery of the opposite semicircle > Press **RTN TO SCREEN**.

