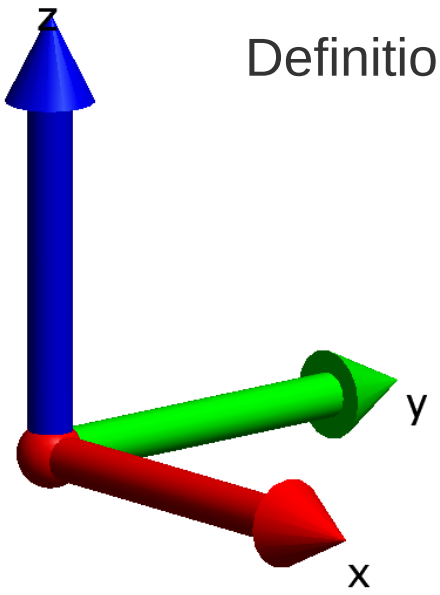
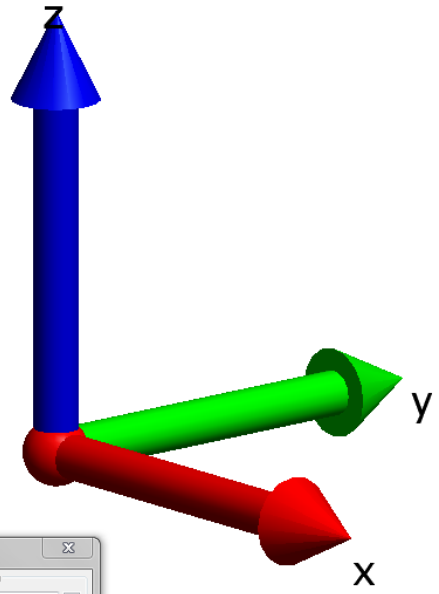
Introduction to Frames

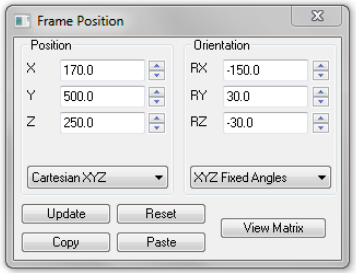


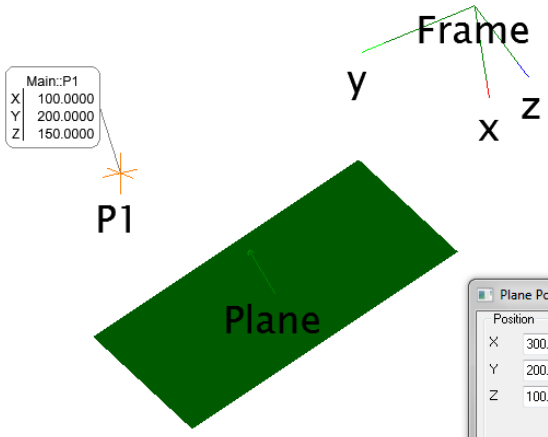
Definition and Measurement

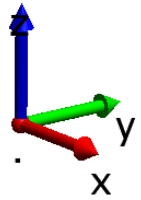
Frames

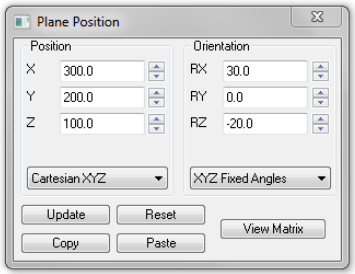
- A frame is a reference system allowing definition of an object's position relative to it
- For a point, only a position is defined (X, Y, Z)
- For more complex objects, orientations can be defined (rotation around each axis)
- A frame can also be defined relative to another frame
- Typically referred to as a 6 Degrees of Freedom (DoF) reference
  - Position – X, Y, Z
  - Rotation – Roll, Pitch, Yaw











Orientation Conventions

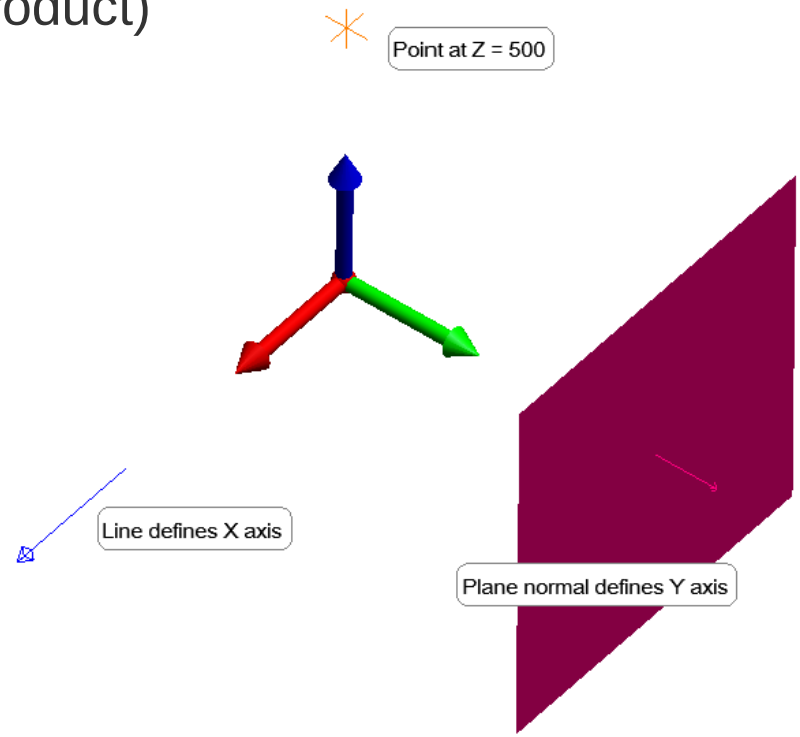
- All axes orthogonal to each other
- Typically use Right Hand Coordinate Systems (defines direction of Y axis relative to X and Z)
- Position along each axis independent of other axes
- Displacements applied in any order
- Orientation around each axis not necessarily independent
- Rotations applied sequentially so order important
- Numerous representations/conventions are used to define these orientations which can all give equivalent final rotations

Examples:

- Roll, Pitch, Yaw (Fixed angle X,Y,Z / Fanuc WPR)
  - Rotate around X axis, then original Y axis, then original Z axis
- Euler ZYX (rotated angle Z,Y,X / KUKA ABC)
  - Rotate around Z axis, then rotated Y axis, then rotated X axis
- Matrix (3 x 3 rotation only, 4 x 4 rotation and position)
  - Absolute definition with no singularities – mathematical representation
- Quaternion (ABB q1,q2,q3,q4)
  - Non-minimal representation
  - No singularities

Defining a frame – Direct

- When measuring a reference frame directly, only 3 pieces of information are required:
  - Direction of primary axis of the frame (vector)
  - Direction of secondary axis of the frame (vector)
  - Known position in the frame (point)
- The tertiary axis is not required as it is calculated from the other 2 (vector cross product)

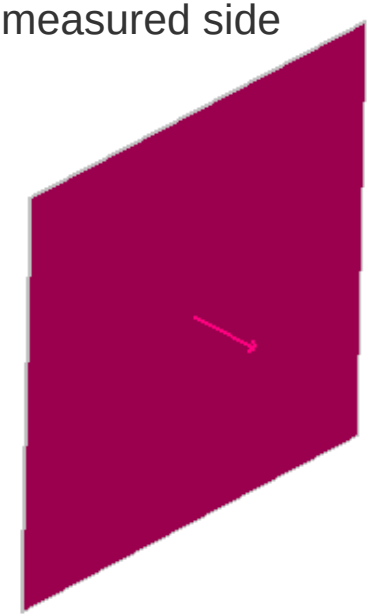


Object Directions

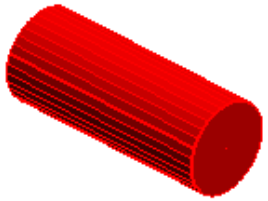
- Direct definition of frames requires directions or vectors
- An object vector can be used for this direction
- Different objects have their vectors defined in different ways
- Positive directions are a function of how the object is measured

Line: first point to last point

Plane: Normal on measured side



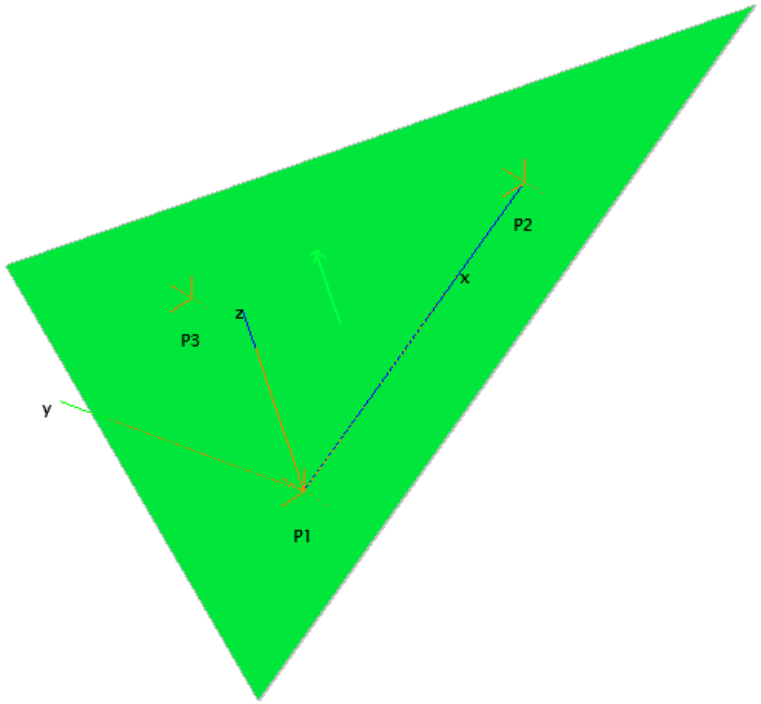
Cylinder: Centre axis

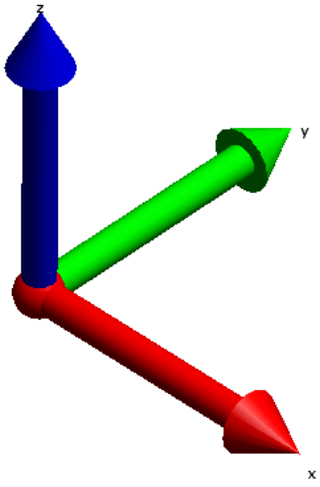


Circle: Normal to circle plane on measured side

Defining a Frame – Indirect

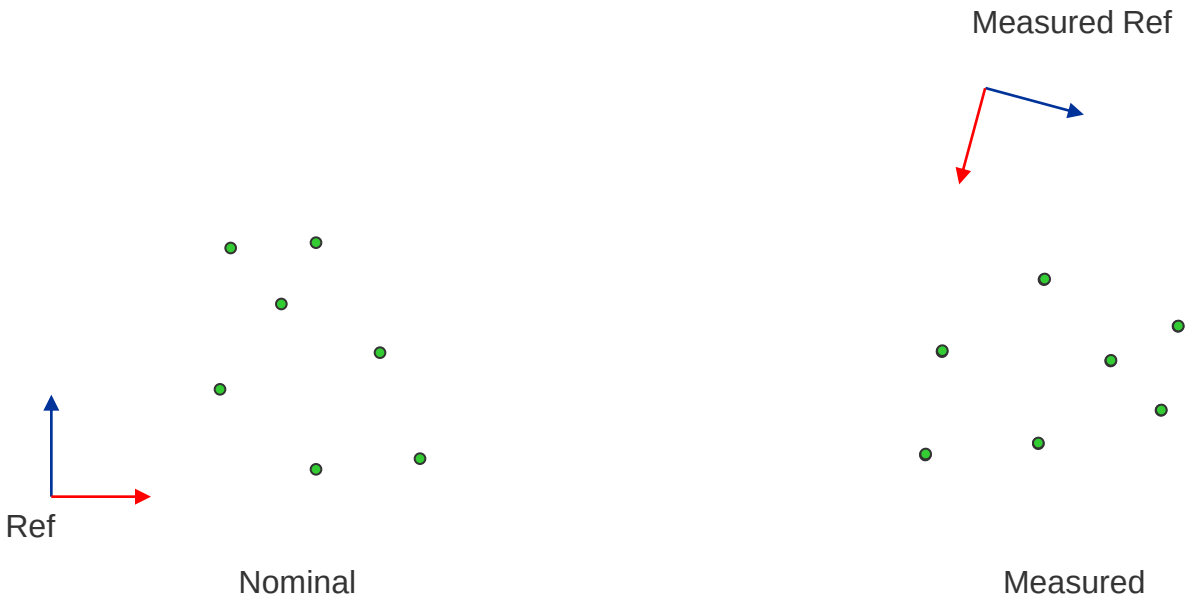
- If three points are measured (P1, P2, P3), a frame can be defined directly as follows:
  - P1 gives an origin (0,0,0)
  - P1 to P2 defines a line (X positive)
  - P1, P2 and P3 define a plane and therefore second direction (Z positive)
- If the position of a second frame is defined relative to this created frame the 3 points can be defined in its coordinates
- Therefore, the second frame can be created by measuring the 3 known points
- The 3 points do not need to be aligned to an axis, just at known positions





Defining a Frame – Indirect

- The creation of the intermediate frame is not required
- If the nominal point positions are known (datums), these can be ‘mapped’ or ‘fitted’ onto the measured points
- This can be applied to measurements of 3 or more known points with the nominal point ‘shape’ fitted to the measured shape effectively moving the reference frame to the measured position
- The points can be points, circle centres, sphere centres, hole centres or LEDs



Dynamic Frame

- A dynamic frame is a Geoloc object that defines LED positions relative to a defined frame
- This turns LED positions into a nominal shape that can then be used to map onto measurements of the same LEDs in a different position
- By attaching LEDs to an object and creating a Dynamic frame, the objects position and orientation can be automatically tracked
- Geoloc's 'Make Frame' function is the reverse of Dynamic Frame
- By measuring LEDs and mapping a Dynamic Frame, the frame that the Dynamic Frame was defined with is created relative to the new LED positions
- Multiple Dynamic Frames can be created with different groups of LEDs
- The frames can be used to track static or dynamic positions of objects or as reference frames themselves