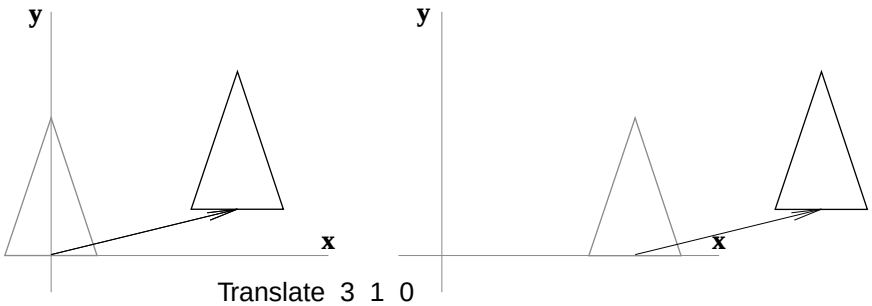
Transformations

There are four basic methods of changing or modifying 3D objects; they can be repositioned, reorientated, resized or distorted in space. These alterations to an object, called *transformations*, are carried out **relative to the origin** of the coordinate system and are known as

- *translation* – moving
- *rotation* – turning
- *scaling* – stretching or squashing
- *skewing* – shearing

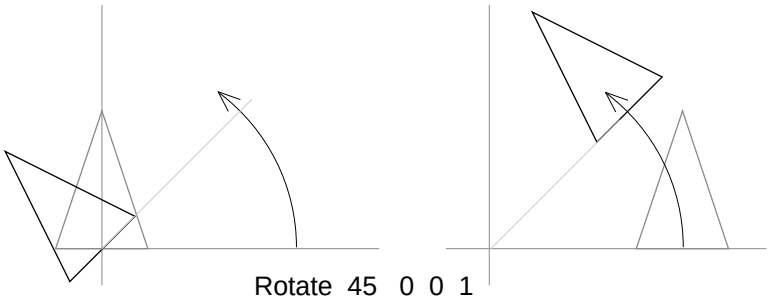
The illustrations show the effect of applying the transformations to two cones that are positioned at the origin and a short distance along the x–axis. In each case the z–axis is pointing "into" the page.

Translation



Translate 3 1 0

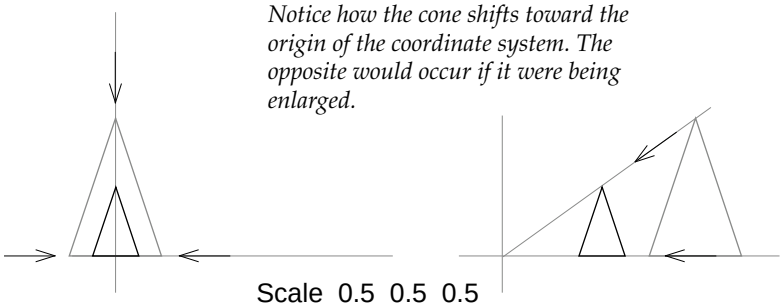
Rotation



Rotate 45 0 0 1

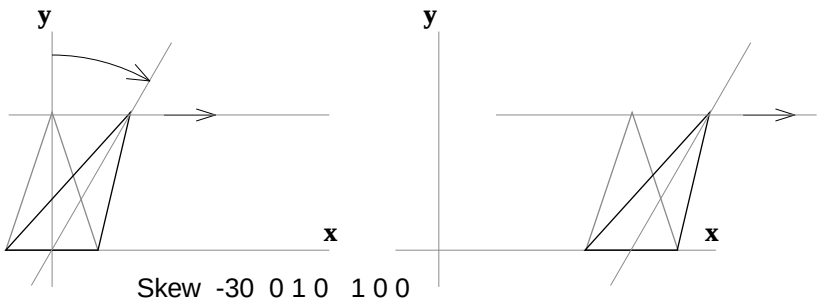
Scaling

Notice how the cone shifts toward the origin of the coordinate system. The opposite would occur if it were being enlarged.



Scale 0.5 0.5 0.5

Skewing



Skew -30 0 1 0 1 0 0

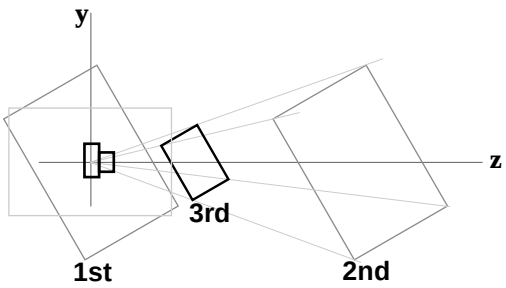
ie. lean the y–axis 30° toward the x–axis

Applying Transformations

Rotating and scaling an object that is NOT positioned at the origin of the coordinate system can give rise to unexpected results. Scaling, for example, has the effect of moving the surface of an object toward or away from the origin depending on whether the object is being reduced or enlarged. If the space into which an object is to be placed is translated, rotated and / or scaled, it normally makes more sense to apply the translation AFTER the rotation and scaling – as shown in the lower drawing.

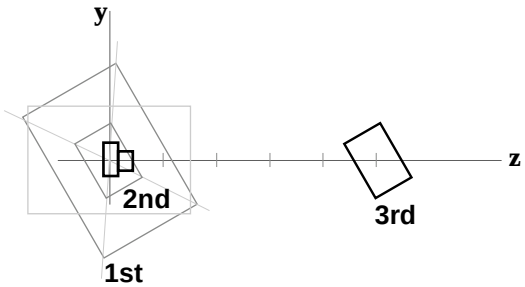
The following illustrations are based on "Getting Started – example 4", they are intended to show how swapping the order in which Scale and Translate are applied results in the cylinder being placed in two entirely different locations in space. In each example the camera is located at the origin of the coordinate system.

The cylinder appears to be large from the viewpoint of the camera



Scale 0.3 0.3 0.3 #3rd
Translate 0 0 5 #2nd
Rotate -120 1 0 0 #1st
Cylinder 1 -1 1 360

Here the cylinder appears to be much smaller

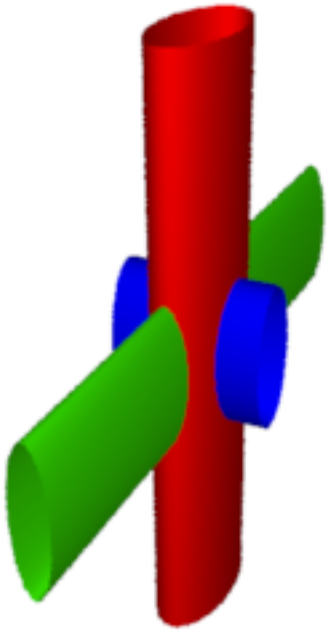


Translate 0 0 5 #3rd
Scale 0.3 0.3 0.3 #2nd
Rotate -120 1 0 0 #1st
Cylinder 1 -1 1 360

Applying Sequencies of Transformations

RIB

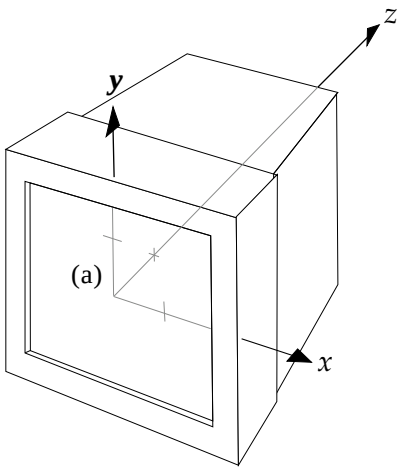
```
Display "3tubes" "framebuffer" "rgb"
Projection "perspective" "fov" 40
Format 400 300 1

WorldBegin
   Translate 0 0 7
   Rotate -110 1 0 0
   Rotate 25  0 0 1

   #insert the upright red cylinder
   Scale .5 1 1
   Color  1 0 0
   Cylinder 0.5 -2 2 360

   #insert the green second cylinder
   Rotate  90 1 0 0
   Scale .5 1 1
   Color  0 1 0
   Cylinder 0.5 -2 2 360

   #insert the blue third cylinder
   Rotate  90 0 1 0
   Scale .5 1 1
   Color   0 0 1
   Cylinder 0.5 -2 2 360
WorldEnd
```



The purpose of this section is to gain a better understanding of the cummulative effect of applying repeated sets of transformations to a modelling space. The RIB file shown above illustrates one of the unexpected results that can occur with transformations. In particular notice how the repeated scaling in the x direction (shown in bold in the RIB script) not only compounds the overall squashing of each tube but also reduces the **length** of the blue tube. This is quite an unexpected result. After all why should the length of the last tube be effected along its z–axis by scalings that have only been applied to the x–axes? The illustrations on the next two pages provide a step-by-step explanation.

Camera space

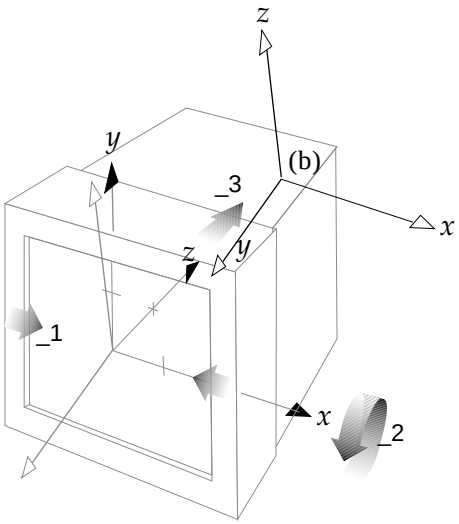
The camera coordinate system may be considered to lie on the surface of the computer screen – as if it were a large view-finder of a virtual camera. At the beginning of the RIB script the axes shown below (a) mark what is called the *current coordinate system*.



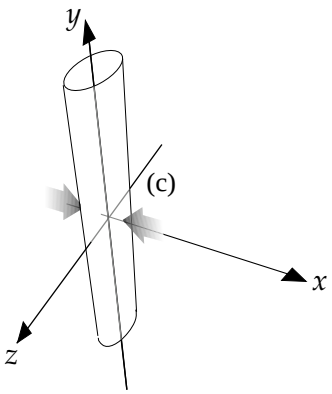
The following RIB statements transform what may be thought of as a **copy** of the current coordinate system **before** the first object is inserted into the world.

```
_3 Translate  0  0  7
_2 Rotate  -110   1 0 0
_1 Scale   0.5  1  1
   Cylinder   0.5  -2  2  360
```

As soon as the cylinder is declared, the transformed copy of the coordinate system (b) becomes the current coordinate system. Subsequent transformations will take place with reference to the new axes (c).



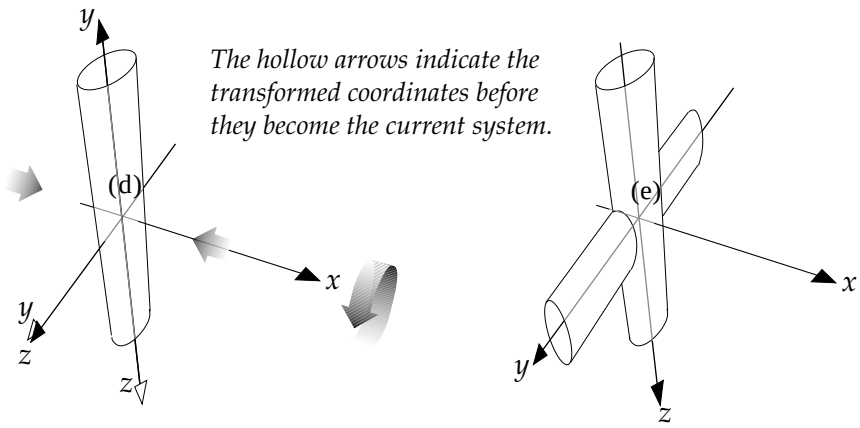
Notice how the x–axis has been scaled by 50%.



The second set of RIB statements shown below transform what again may be thought of as a copy of the current coordinate system.

```
Rotate  90   1 0 0
Scale   .5  1  1
Cylinder   0.5  -2  2  360
```

Once again as soon as the second cylinder is declared, the copy of the coordinate system (d) becomes the current coordinate system (e). Notice the x–axis has received a further reduction in scale.



The last set of RIB statements apply the final transformations prior to inserting the third cylinder.

```
Rotate  90   0 1 0
Scale   .5  1  1
Cylinder   0.5  -2  2  360
```

Again the x–axis of the modelling space receives another reduction in scale. However, because of the rotation of the coordinate system around the y–axis, the final cylinder is inserted parallel to a coordinate axis that has been considerably squashed – hence the dramatic reduction in the length of the cylinder.