SOEM 024: Computer Aided Design

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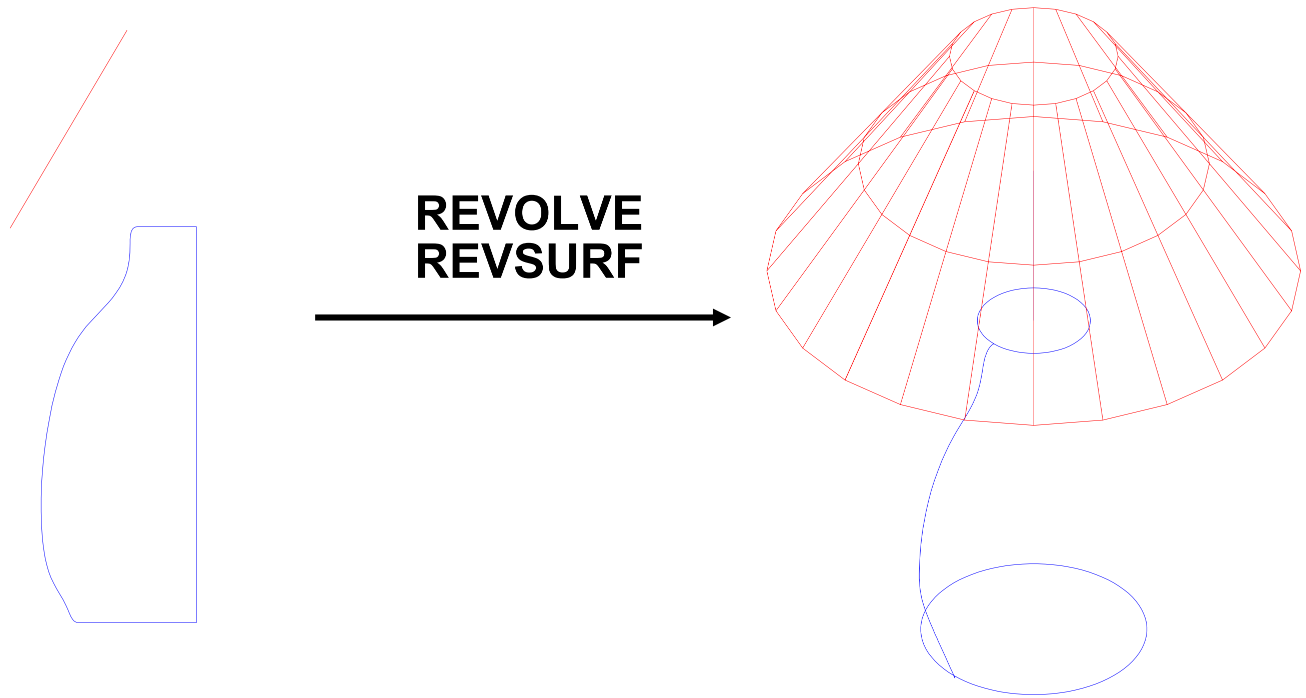
Lesson structure

- Construct 3D objects with revolving
- WCS – UCS
- Master plotting
- Realism
- Geometrical analysis
- Stress analysis
- Kinematics – dynamic simulation

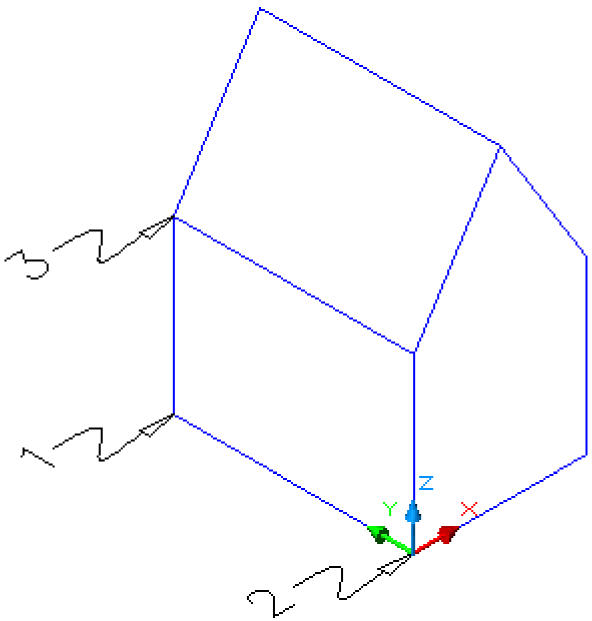
Revolve, revsurf

A revolved region produces a solid (REVOLVE). A revolved curve produces 3D surface (REVSURF).



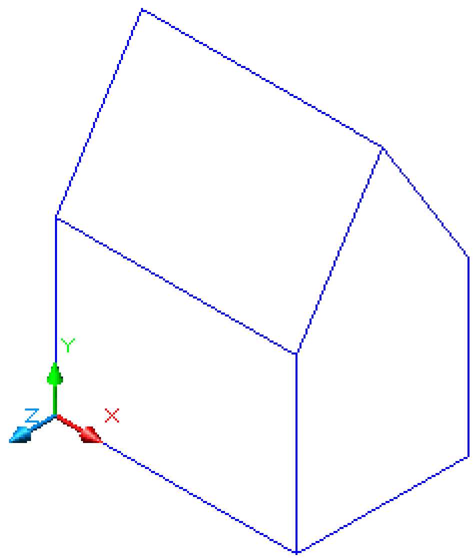
Change from WCS to UCS

When working in 3D, sometimes is convenient to move the axes origin to a characteristic point of the draw. For example, if you need to add some details to a wall it would be easier to use relative coordinates having the (0,0) on one of the corners.



WCS

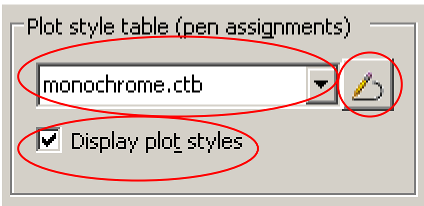
Command: UCS
Current ucs name: *NO NAME*
Enter an option
[New/Move/orthoGraphic/Prev/Restore/Save/
Del/Apply/?/World] <World>: 3
Specify new origin point <0,0,0>: (P1)
Specify point on positive portion of X-axis
<1.0000,7.0000,0.0000>: (P2)
Specify point on positive-Y portion of the
UCS XY plane
<1.0000,7.0000,0.0000>: (P3)



UCS

Master plotting - Pens

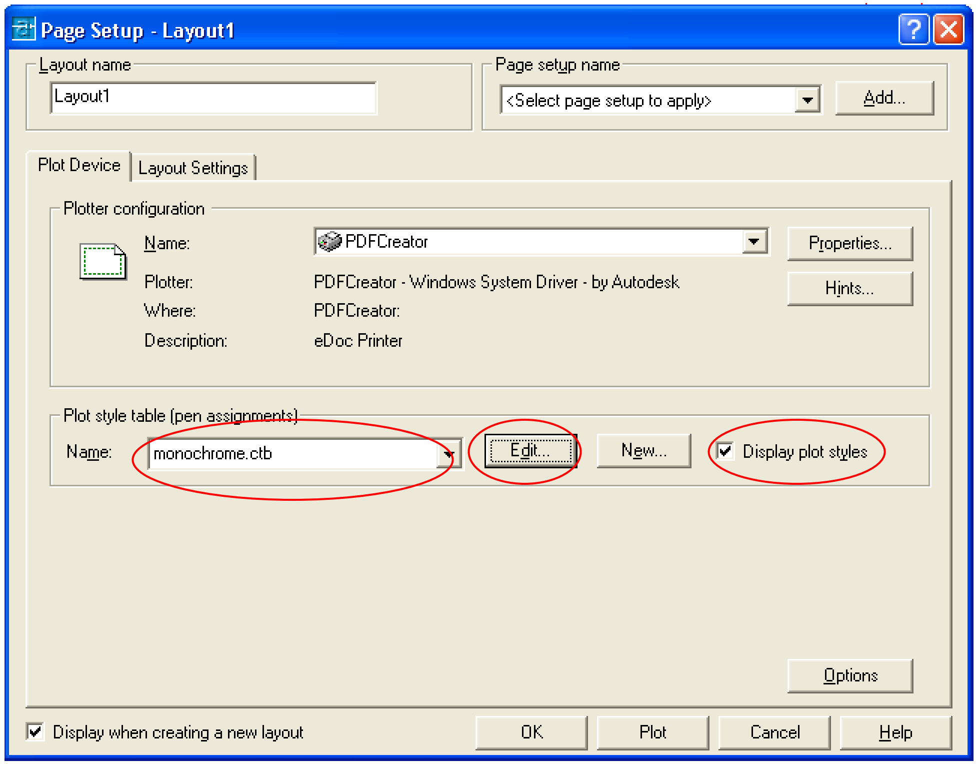
The following two layers with green and red colours are plotted using thin and fat pens.

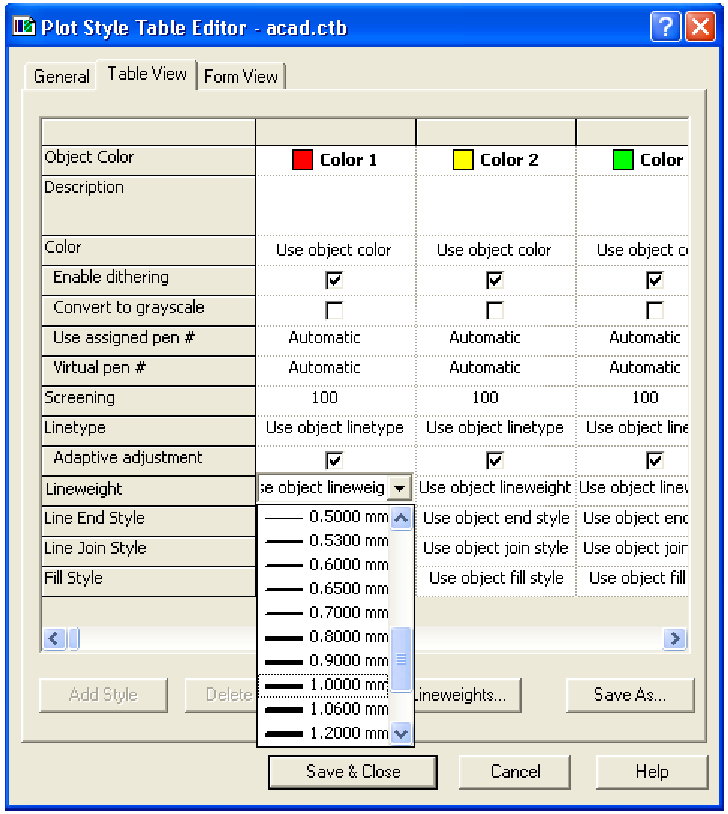
To define (Autocad 2007) the pens that correspond to each colour in the drawing give the command PAGESETUP → choose Modify → 

→ press  → to change the pen weights.

Master plotting - Pens

Assign pens in AutoCad 2002. Type PAGESETUP and modify the settings as shown bellow.





Master plotting - LineWeights

Lineweights may be defined:

1. for each layer in the “Layer Properties Manager” dialog box (open it with LA).
2. for each separate object by modifying the object properties.
3. for each colour using the colour depended plot style.
4. for each layer or object using the named plot style.

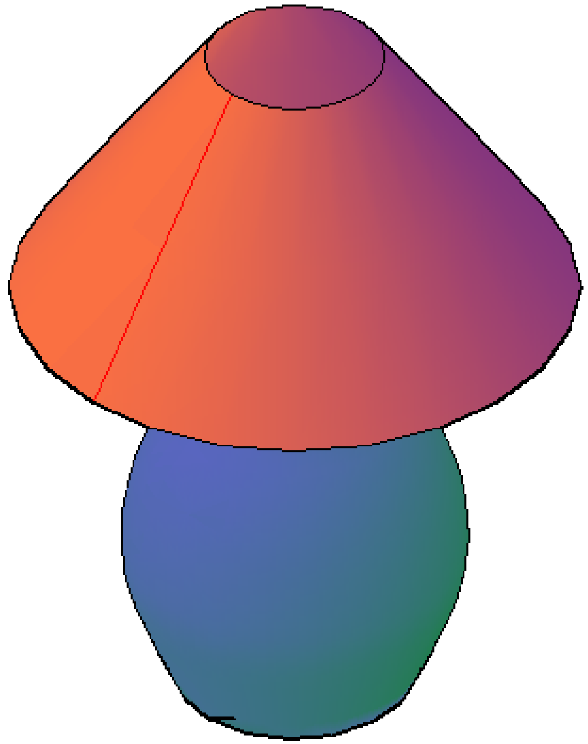
In the last two slides actually we were describing colour plot styles (.ctb). Named plot styles (.stb) map pen colours and lineweights to objects or layers based on a specific plot style that is assigned to the object.

Tip: Turn LWT on to see the objects drawn with lineweights

Master plotting – 3D view

The visual style that will be used during the plotting of an object is controlled by the properties of the vieweport in the layout tab.

1. The depicted object was plotted in AutoCad 2007 having set the viewport property “Shade plot” to “Conceptual”.
2. In AutoCad 2002 you can only select to plot having set the hide on.



Applying materials

Switch to “3D Modeling” workspace (Tools → Workspaces → 3D Modeling). You will see that two new palettes are added. Close the one on the right for drawing and leave the one that contains a list of materials. To add a material to the cube, click on the icon of the material you want to use and apply it to the object.

Box 120×120×240, materialMasonry.Unit Masonry.Brick.Modular.Stack

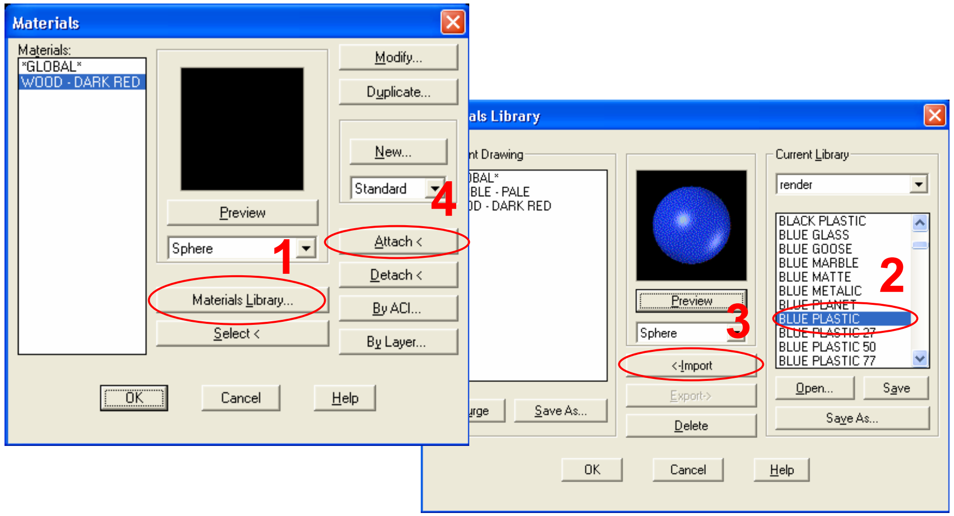
Map materials to objects

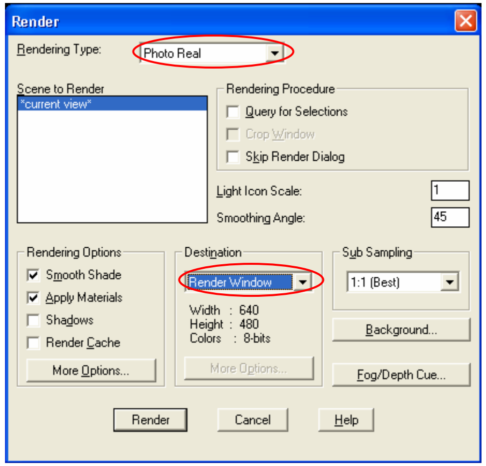
Type VSCURRENT and choose Realistic to be the current visual style. Type MATERIALMAP and select Box to map the material to the scale of object. Draw the grips (click to select, draw, click to accept) to adjust the material scale and press <Enter> when finished. Type RENDER to check the results.

Box 120×120×240, materialMasonry.Unit Masonry.Brick.Modular.Stack

Applying materials (Acad 2002)

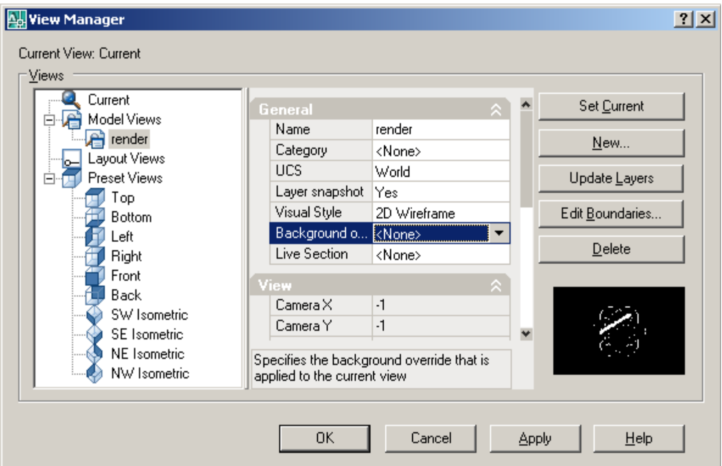
Type RMAT and open the "Materials Library". Select a material, "Import" to the "Current Drawing" and press OK. Back in the "Materials" dialog box press "Attach", select a 3D object, press <Enter> and exit the dialog box. Type RENDER to see the results.





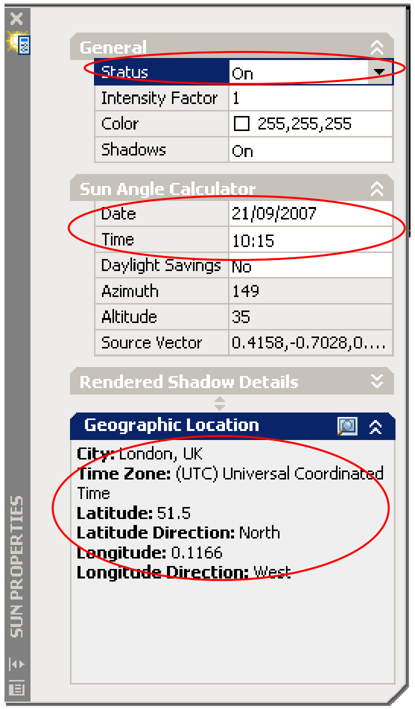
Advanced realism - background

From "View Manager" dialog box (command V) a background can be added to the view.



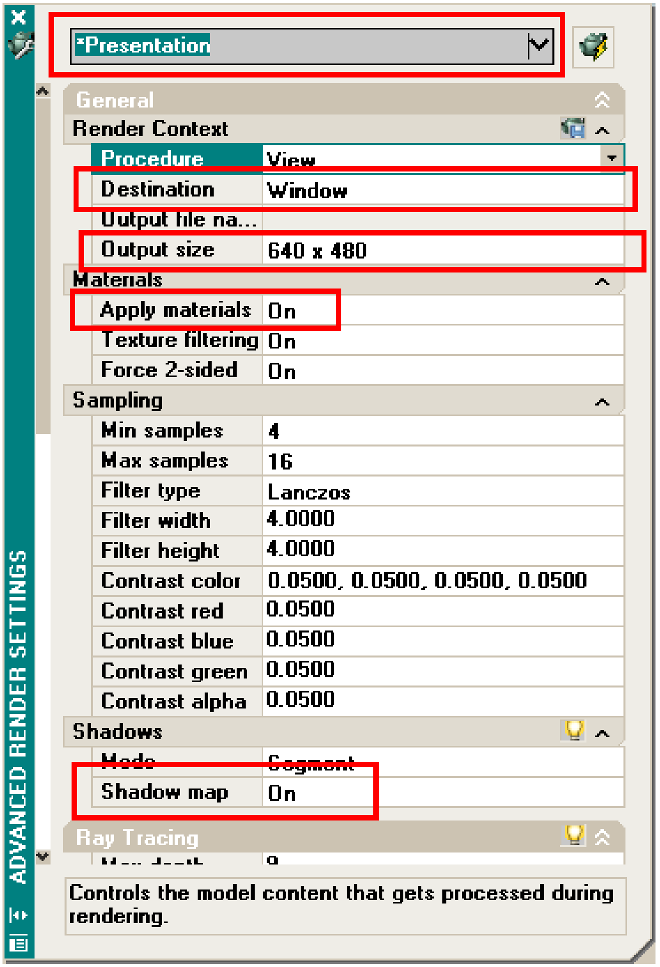
Advanced realism - sunlight

The properties of sunlight may be defined from the "Sun Properties" (View > Render > Light > Sun Properties).



Advanced realism – fine tuning

You can adjust the rendering settings using the RPREF command. For the best quality settings select “Presentation”. The light type is defined with the LIGHT command.



Design analysis

- Geometrical analysis (evaluation of volumes, areas, lengths)
- Stress analysis (evaluation of tensions and shear forces)
- Kinematical analysis (study of movement translations through the object)

Geometrical analysis

The geometry of an object can be analysed with the MASSPROP command. The command give information about:

1. the object volume ($V = \sum E_S W_S$, where E_S area of slab face, W_S slab thickness).
2. the object centroid ($\mathbf{R} = 1/M \sum m_i \mathbf{r}_i$, where M the total mass, m_i the mass of particle i, $\mathbf{r}_i$ the position of particle i)
3. the moments of inertia I_{XX}, I_{YY}, I_{ZZ} (the diagonal terms of inertia tensor e.g. I_{XX} is the moment of inertia around the x-axis when the objects are rotated around the x-axis, $I_{XX} = \sum m_i(y_i^2+z_i^2)$, where y_i, z_i the distance of the particle from the y and z axis).

Geometrical analysis

4. Products of inertia I_{XY}, I_{XZ}, I_{YZ} (off diagonal terms of inertia tensor e.g. I_{XY} is the moment of inertia around the y-axis when the objects are rotated around the x-axis, $I_{XY}=\Sigma m_i x_i y_i$)
5. Radii of gyration (the radial distance at which the mass of a body could be concentrated without altering the rotational inertia of the body, $R_X = \sqrt{(I_{XX}/A_{YZ})}$.

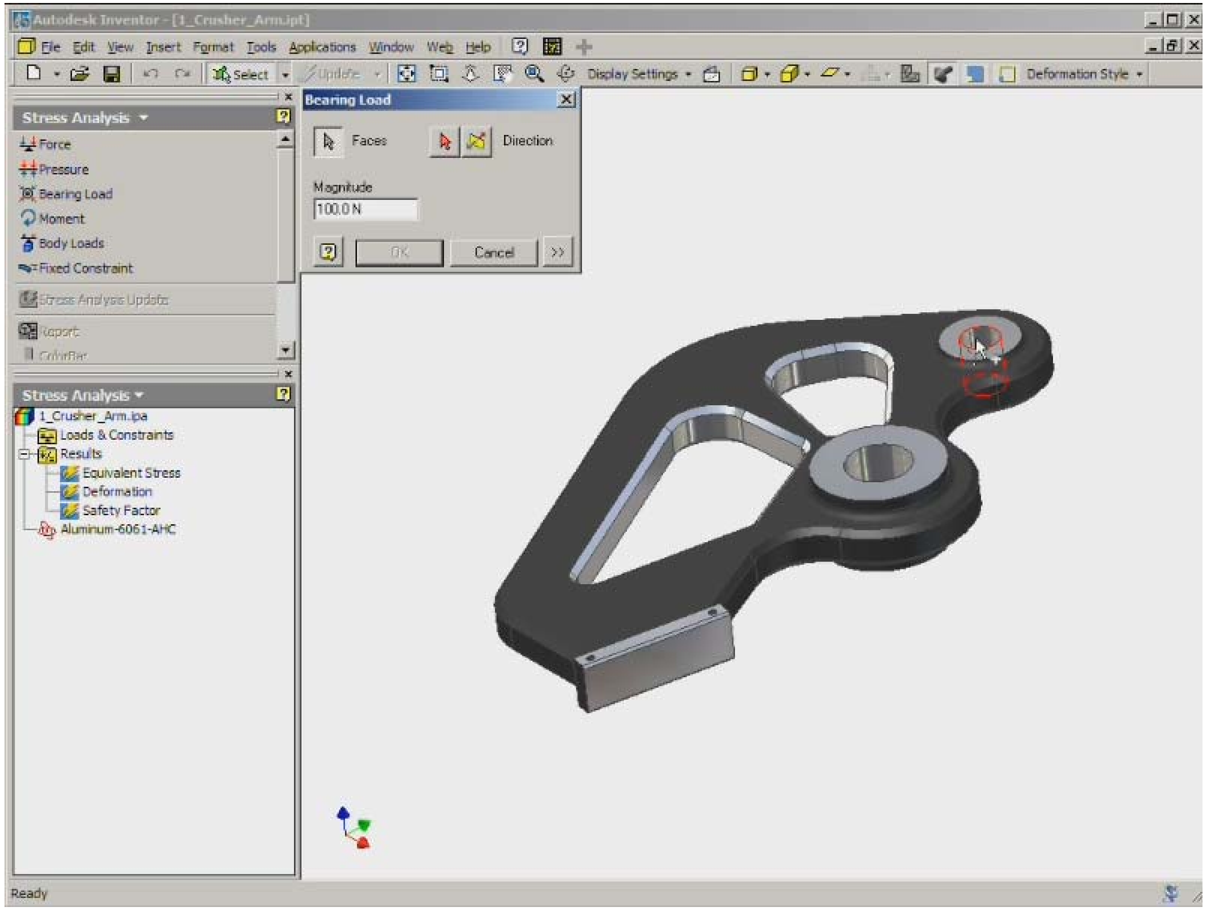
Stress analysis

Verify that a part will be strong enough without having to build a prototype. Modern CAD systems are fully integrated with FEA applications and provide:

1. the interface to describe the real world working conditions that the part must endure i.e. pressure, bearing loads, fixed constrains.
2. automatically FEA mesh generation.
3. the capability for final adjustments to tailor the analysis to better shot the part in question.
4. the material library.
5. visual evaluation of FEA results.

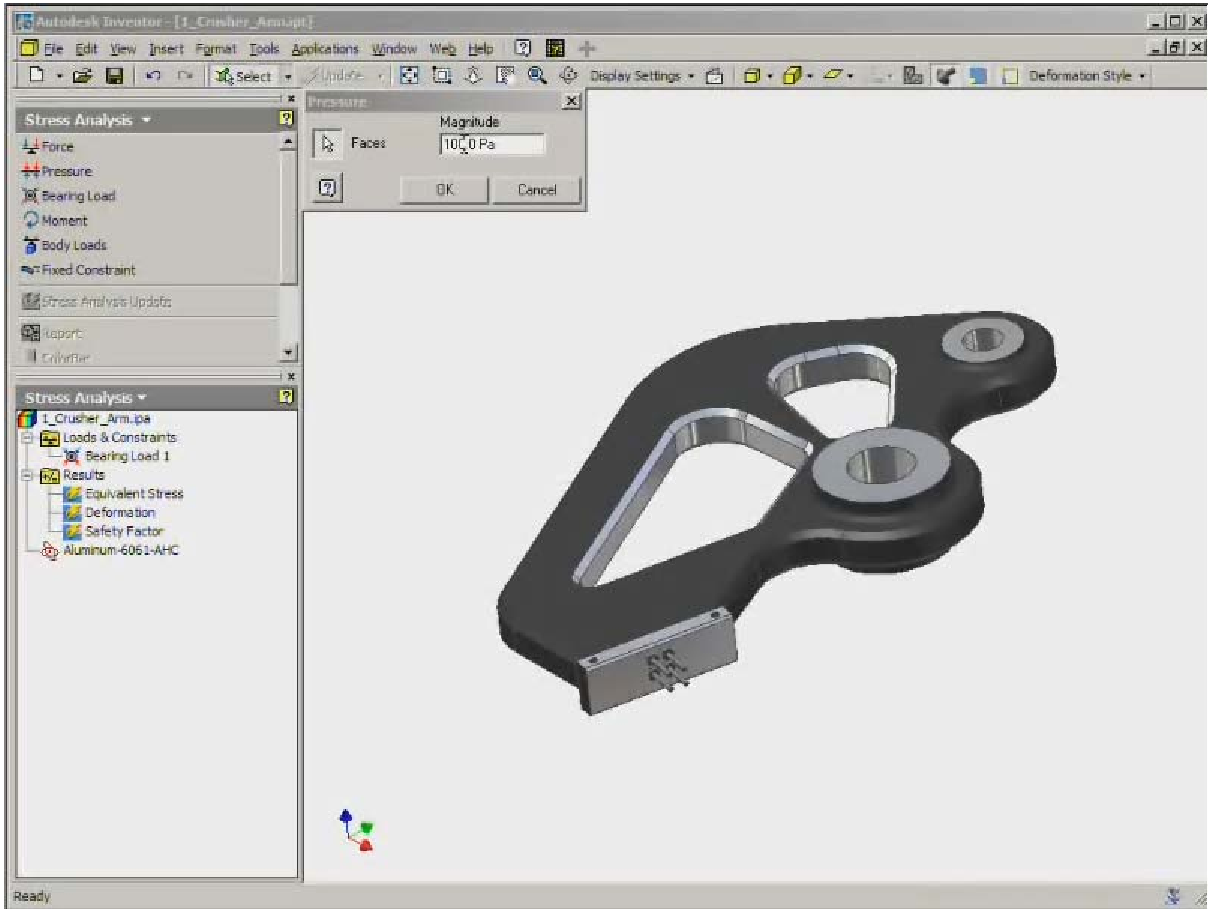
Define stresses-constrains

Define bearing load.



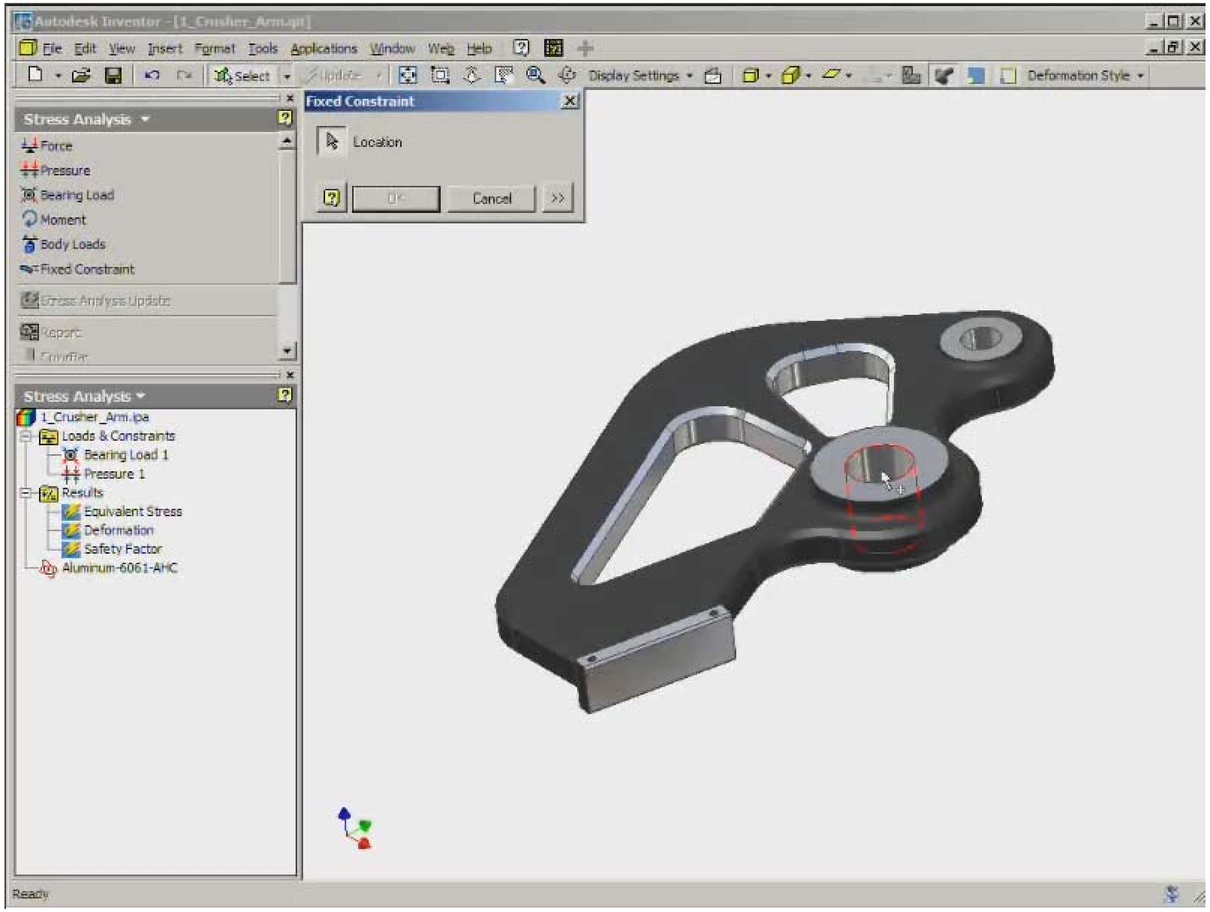
Define stresses-constrains

Define pressure.



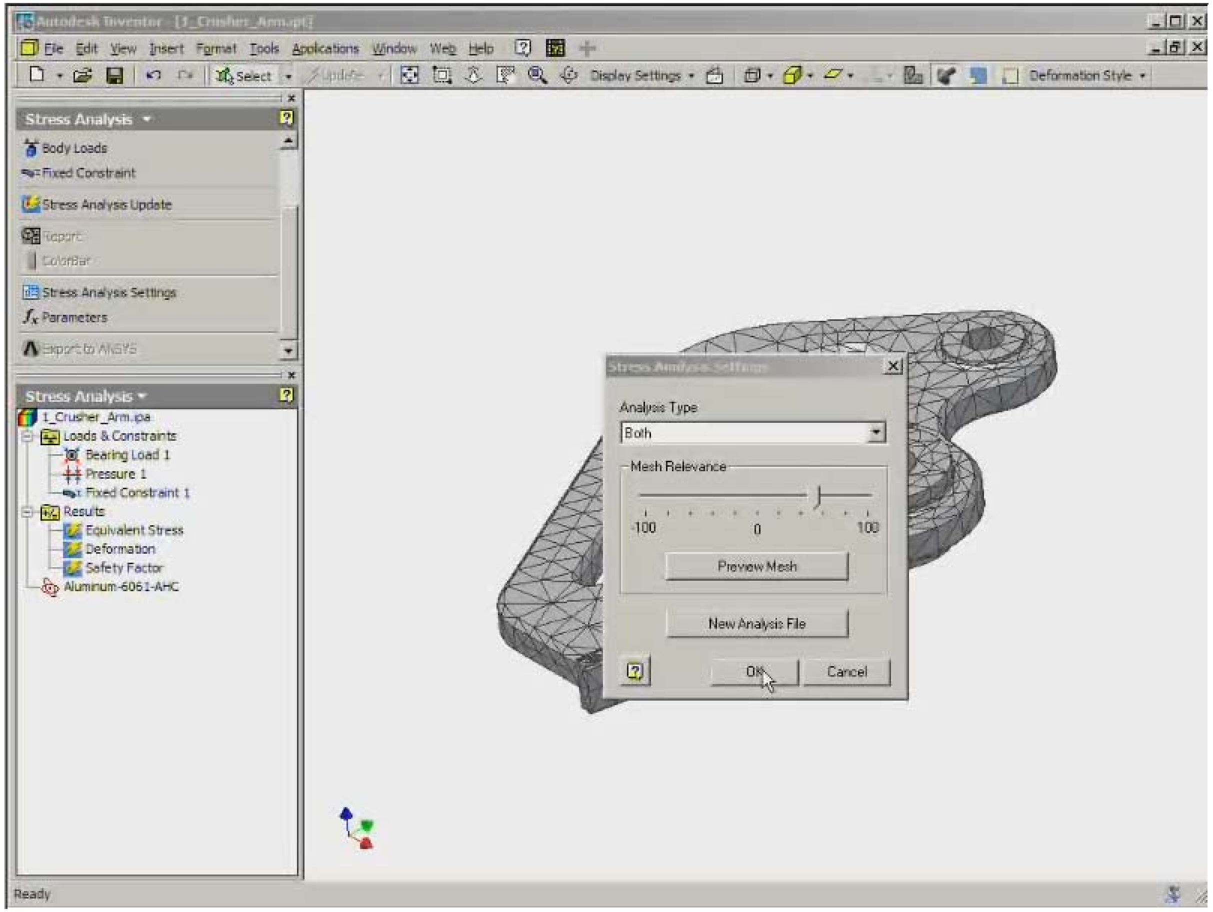
Define stresses-constrains

Define constrain.



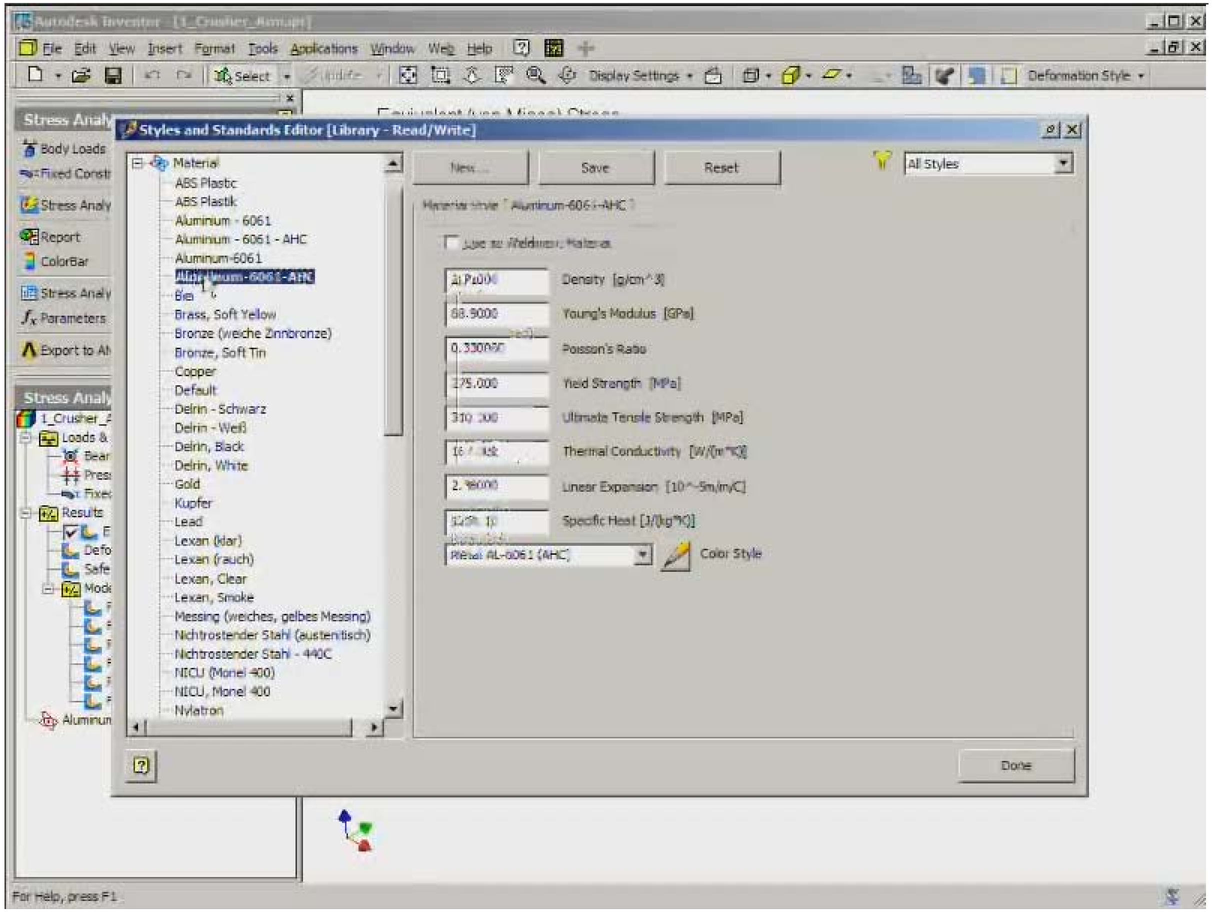
Mesh generation

Automatic mesh generation and adjustment.



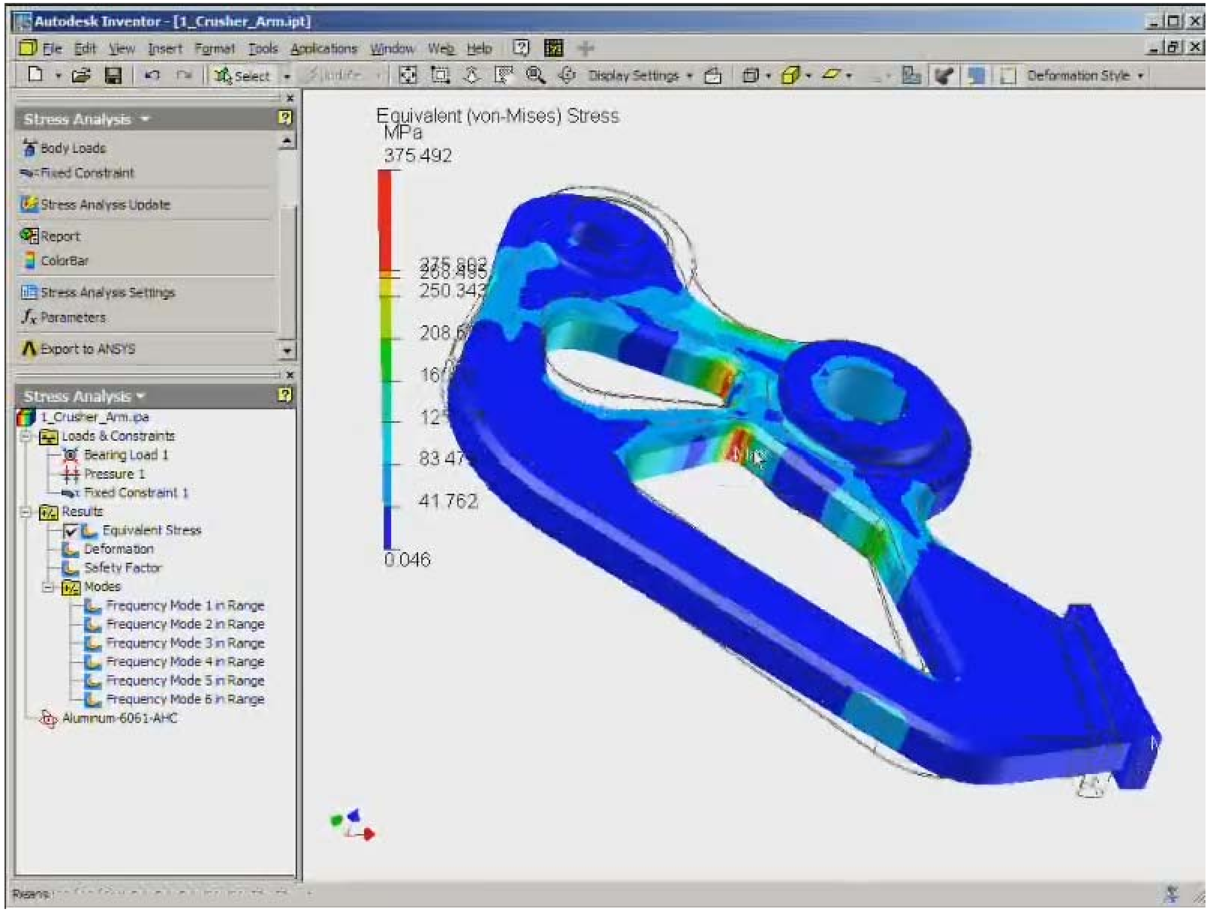
Material selection

Select material from material library.



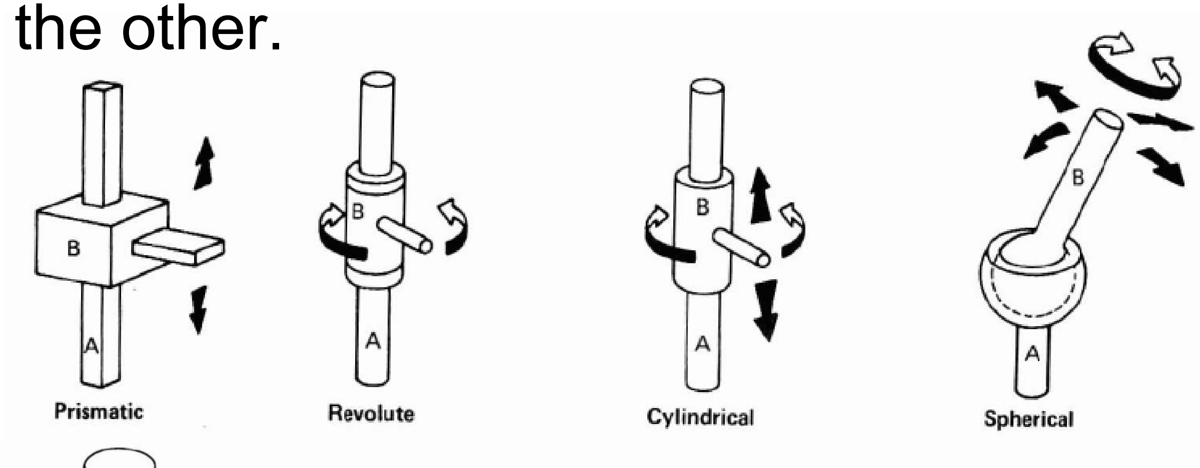
Indicate violations

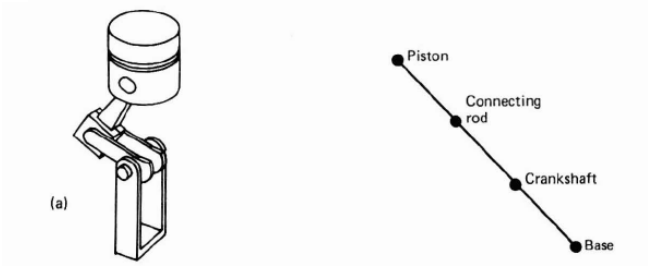
Stress exceeds material requirements.



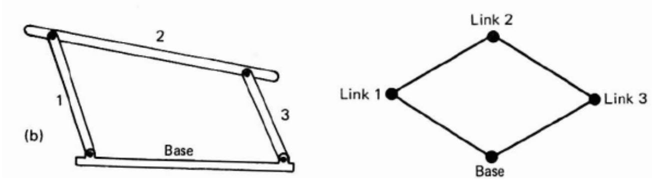
Kinematics

A joint defines a family of rigid transformations of one link to the other.



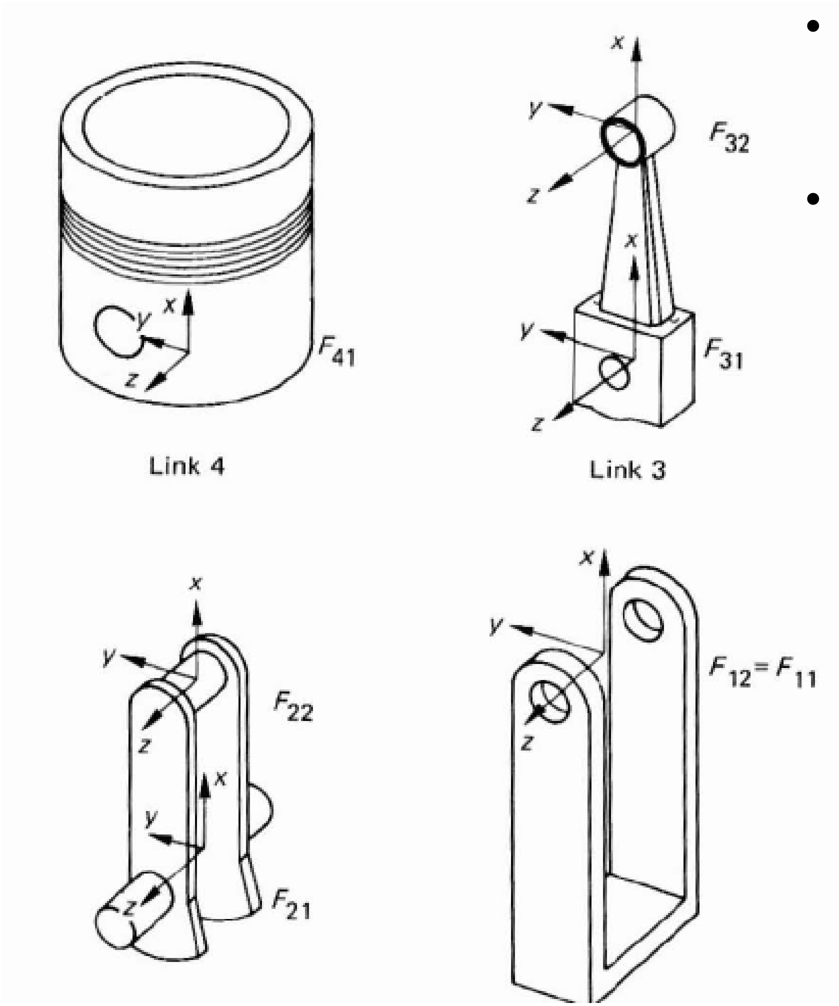


Open-loop mechanism (the joint graph is a tree)



Closed-loop mechanism. The joint graph is cyclic

Kinematics



- T transformations relate different coordinate system which are embedded in the same link.
- $U_k(\boldsymbol{\alpha})$ transformations relate coordinate systems associated with different links, k denotes the joint type and **α** the variables which express the relative position and orientation of the two links meeting at the joint.

$$
\begin{aligned}
F_{41} &= U_r(\gamma)\, F_{32} \\
&= U_r(\gamma)\, T_{312}\, F_{31} \\
&= U_r(\gamma)\, T_{312}\, U_r(\beta)\, F_{22} \\
&= U_r(\gamma)\, T_{312}\, U_r(\beta)\, T_{212}\, F_{21} \\
&= U_r(\gamma)\, T_{312}\, U_r(\beta)\, T_{212}\, U_r(\alpha)\, F_{12}
\end{aligned}
$$

U_r denotes transformation associated with revolute joint and α, β, γ are the angular displacements.

Dynamic simulation

Visualise how the moving parts of your design will work without the need of physical prototype. A dynamic simulation includes:

1. the definition of joints from motion joint library.
2. the application of driving loads or time-based force functions on the appropriate design components.
3. the determination of the accurate components position to ensure sufficient clearance between mechanisms and fixed structures.
4. the calculation of the dynamic operating conditions of the design throughout its full operating cycle
5. the analysis of the motion values including positions, velocities, accelerations and loads.

Dynamic simulation