Solid – surface modeling in AutoCAD

Introduction into 3D modeling
Managing views of 3D model
Coordinate Systems
3D model advantages

• ability to view the whole model
• looking inside the model
• collision checking
• element overlapping check
• automatically generated plans and sections
• realistic visualisation of the model
• automatically generated material, area and volume lists
Types of 3D models in AutoCAD

- **wireframe model** – model is constructed from lines that form frame of the model
- **surface model** – consists of edges and non transparent faces that form external boundaries of the model
- **solid model** – consists of edges, surfaces and solids (primitives with non zero volume) – closest to reality; physical parameters such as mass, volume, center of gravity, inertia moments can be derived from solid model
• **wireframe model** – formed from lines (LINE, POLILINE, POLILINE3D tools). Useful in designing e.g. infrastructure.

• **surface model** – formed from infinitesimally thin shells representing external surfaces and planes of the model. We apply different techniques, such as: extrusion or use predefined primitives (e.g. cube, cone)

Surface models can be created with the use of solid modeling techniques (e.g. sweeping, extruding open elements).

**Mesh models (meshes) are special case of surface models** – an element is represented by grid of edges and faces.

By using mesh tools we are able to freely control shape of our model by creasing, smoothing, refining – techniques unavailable in solid modeling.
• **solid model** – element is represented as a volume, the most faithful representation of reality.

Solid modeling is easier than wireframe and mesh modeling. **Solids may be added, substracted, intersected.**

While modeling solids we can use predefined primitives: cube, cone, cylinder, sphere, extrude any 2D shape along line, arch or polyline path and revolve around an axis.

**Drawback of solid modeling**

There is no free-form modeling (solid shaping) that is available in surface modeling.
3D modeling in AutoCAD is based on

- cartesian coordinate system: x, y, z
- cylindrical coordinates: r <φ, z
- spherical coordinates: r <φ <q

**Coordinates** can be defined as

- absolute values (measured from current UCS)
- relative values (measured from recently created point)

**Remarks:**

In cylindrical and spherical coordinate systems **ONLY radius** can be defined as a relative coordinate.

Angles are always received as absolute values.
Coordinates relate (as default) to Global Coordinate System, that is fixed and constant in the model (GCS icon in left bottom corner).

While creating 2D drawings we operate in XY plane, forgetting about „Z” axis (it is equal to „0” for the drawing).

While modeling in 3D we create elements typing all 3 coordinates (directly or as default).
Active plane is XY plane of currently defined coordinate system. The new element (line or rectangle) will be created on that plane.

To create an element on other plane we have to define new position for XY plane previously – define new coordinate system.

We can define any amount of User Coordinate Systems.

We shall keep in mind that at a moment there is only one active UCS.
Solids below have been modeled in different coordinate systems. **Cone** was created in **GCS**, its base is on the XY plane of the GCS. **Pyramid** was modeled in the UCS1, base of the pyramid is on the XY plane of UCS1. **Cuboid** was modeled in UCS2. Cylinder in UCS3. Bases of those solids are on XY planes of respective UCS.

![Diagram showing different coordinate systems and solids](image-url)
RESUME

• in 3D space we operate by using User Coordinate Systems

• 2D elements are always placed on XY plane of current UCS

• base of 3D solid primitive is placed on XY plane of current UCS, Z axis shows height direction.

• 2D edit tools are valid only on the XY plane of current UCS (e.g. move, copy, rotate).

• 3D edit tools (3D rotate, 3D mirror) allow element edition outside XY plane.
Views control tools in the model space
Views control tools – in the top right corner of model space

We have **three tools** on the right side:
- **ViewCube** with Home button
- **navigation menu**
- **Full Navigation Wheel**

**ViewCube** tool – allows 3D model point of view change by choosing edges, corners or faces of the cube.

Home button – above ViewCube.

**NOTE:**
You can redefine your home view.
**SteeringWheels tool**

SteeringWheels are menus that track the cursor over the drawing window, and provide access to 2D and 3D navigation tools from a single interface.

SteeringWheels, or “wheels,” are divided into **wedges**; each wedge contains a single navigation tool. You can start a navigation tool by clicking a wedge or by clicking and dragging the cursor over a wedge.

Right-click on the wheel to view shortcuts.
Navigation menu

Navigation menu comprises of:

- **SteeringWheel**
- **Pan tool**
- **Zoom window**

**Constrained 3D orbit** - When 3DORBIT is active, the target of the view stays stationary and the camera location, or point of view, moves around the target. However, from the user's point of view, it appears as if the 3D model is turning as the mouse cursor is dragged. In this way, you can specify any view of the model.

**3D Free Orbit** – Rotates the view in 3D space without constraining roll.

**3D Continous Orbit** - Rotates the view in 3D space with continuous motion.
VIEW command (View manager)

Easy access to commonly used views allows space orientation:
• top and bottom view
• side views
• isometric views

NOTE:
Named views in AutoCAD have their own UCS defined
Models can be viewed with different styles (different accuracy). The bigger accuracy the better quality of view, however image generation becomes more time consuming.
Realistic

Conceptual
3D modeling interface

- Navigate panel
- Appearance panel
- Coordinate panel
- Visual Styles panel
3D modeling interface panel

Classic toolbar

- Rotate around axis X
- Rotate around axis Y
- Rotate around axis Z
**UCS**

3D modeling interface panel

**View** - Establishes a new UCS whose XY plane is perpendicular to your viewing direction (e.g. parallel to your screen).

**PLAN** - Displays the plan view of a specified user coordinate system
UCS – specify origin of UCS – define new (0,0,0) to facilitate dimension and coordinate entry
**Z Axis** - Aligns the user coordinate system to a specified positive Z axis. The UCS origin is moved to the first point specified and its positive Z axis passes through the second point specified.
**Z Axis** - Defines a new UCS using one, two, or three points. If you specify a single point, the origin of the current UCS shifts without changing the orientation of the X, Y, and Z axes.
**UCS [from User’s Guide]**

**Understand the User Coordinate System in 3D**

When you work in 3D, the user coordinate system is useful for entering coordinates, creating 3D objects on 2D workplanes, and rotating objects in 3D.

When you create or modify objects in a 3D environment, you can move and reorient the UCS in 3D model space to simplify your work. The $XY$ plane of the UCS is called the workplane.

Important operations on objects in a 3D environment that depend on the location and orientation of the UCS include the following:

• Establish the workplane in on which to create and modify objects
• Establish the workplane that contains the grid display and grid snap
• Establish a new UCS $Z$ axis about which to rotate objects in 3D
• Determine up and down directions as well as horizontal and vertical for Ortho mode, polar tracking, and object snap tracking
• Define a 3D view directly into the workplane with the PLAN command
UCS [from User’s Guide]

Apply the Right-Hand Rule

Use the right-hand rule to determine the positive axis direction of the Z axis when you know the direction of the X and Y axes in a 3D coordinate system. Place the back of your right hand near the screen and point your thumb in the direction of the positive X axis. Extend your index and middle fingers as illustrated, pointing your index finger in the direction of the positive Y axis. Your middle finger indicates the direction of the positive Z axis. By rotating your hand, you see how the X, Y, and Z axes rotate as you change the UCS.

You can also use the right-hand rule for determining the default positive direction of rotation about an axis in 3D space. Point your right thumb in the positive direction of the axis and curl your fingers. Your fingers indicate the positive rotation direction about the axis.

Note
By default, when you specify a view in 3D, it is established relative to the fixed WCS rather than the movable UCS.