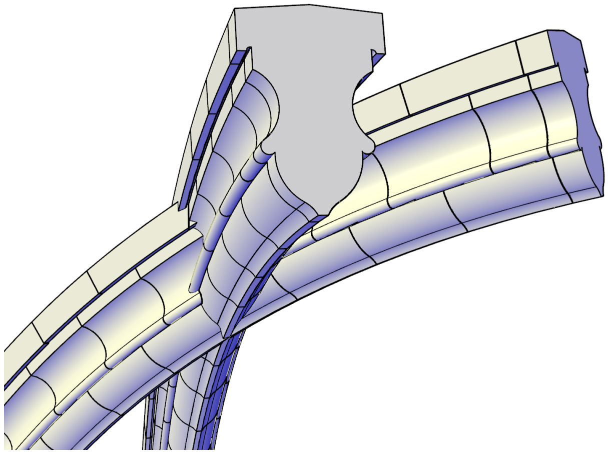
MŰEGYETEM 1782

Strommer László

Constructive CAD C



This work is connected to the scientific program of the "Development of quality-oriented and harmonized R+D+I strategy and functional model at BME" project.
This project is supported by the New Hungary Development Plan (Project ID: TÁMOP-4.2.1/B-09/1/KMR-2010-0002).

BUDAPEST, 2012.

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1 Surface Models

1.1 2.5D Surface Modelling

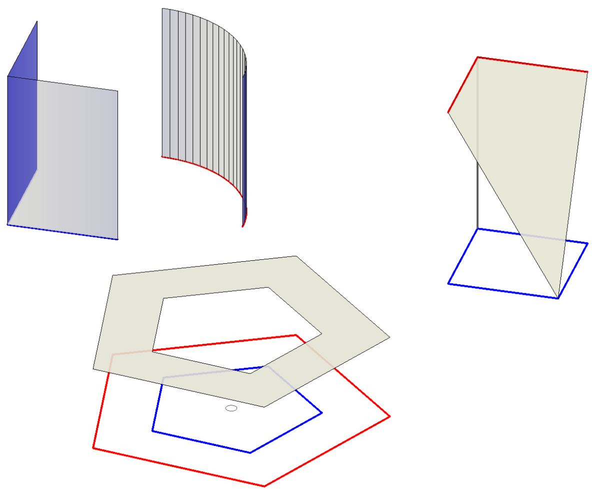
- ◦ THICKNESS ▷ the thickness property can be used to give 2D objects a 3D height
- • REGION ▷ converts an object that encloses an area into a 2D REGION object

▷ the result is a 2D surface that can be modified using Boolean operations

- ◦ DELOBJ ▷ controls whether geometry used to create 3D objects is retained or deleted

1.2 Basic (Legacy) Surface Modelling

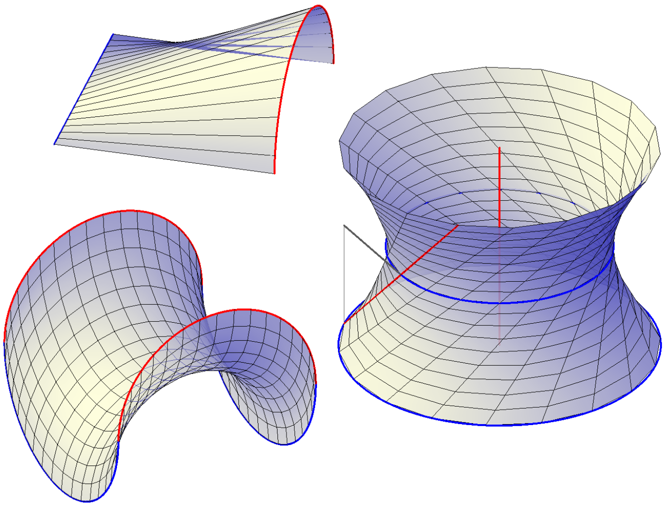
- 3DFACE ▷ creates a three-sided or four-sided surface in 3D space
- EDGE ▷ toggles the visibility of 3DFACE edges
- PFACE ▷ creates a mesh with multiple vertices defined by coordinates that you specify



1. THICKNESS
2. 3DFACE
3. PFACE

```
PFace
4<90 4<162 4<234 4<306 4<18 7<90 7<162 7<234 7<306 7<18
-1 6 -7 2 -2 7 -8 3 -3 8 -9 4 -4 9 -10 5 -5 10 -6 1
```

Legacy Surface Modelling



1. RULESURF
2. REVSURF
3. EDGESURF

▷ SURFTAB1
▷ SURFTAB2
mesh density
in N and M direction
▷ MESHTYPE
type of mesh
(0 = legacy polyface)

- RULESURF ▷ creates a mesh between two edges (e.g. conoid-like surfaces)
- EDGESURF ▷ creates a mesh between four adjoining edges (e.g. translational surface)
- REVSURF ▷ revolves a profile about an axis (e.g. hyperboloid of revolution)

1.3 Advanced Surface Modelling

Procedural Surfaces can be associative, maintaining relationships with other objects so that they can be manipulated as a group, while **NURBS Surfaces** have control vertices

- EXTRUDE ▷ creates a 3D surface (or solid) by extending the dimensions of an object
- LOFT ▷ creates a 3D surface (or solid) in the space between several cross sections
- REVOLVE ▷ creates a 3D surface (or solid) by sweeping an object around an axis
- SWEEP ▷ creates a 3D surface (or solid) by sweeping a 2D or 3D (sub)object along a path
- PLANESURF ▷ creates a planar surface
- SURFNETWORK ▷ creates a surface in the space between several curves in the U and V directions (including surface and solid edge subobjects)
- SURFBLEND ▷ creates a continuous blend surface between two existing surfaces
- SURFEXTEND ▷ lengthens a surface by a specified distance
- SURFFILLET ▷ creates a filleted surface between two other surfaces
- SURFOFFSET ▷ creates a parallel surface a specified distance from the original surface
- SURFPATCH ▷ creates a surface by fitting a cap over a surface edge that forms a closed loop

- SURFTRIM • SURFUNTRIM ▷ trims portions of a surface where it meets another surface or type of geometry, or replaces the removed surface areas

◦ SURFACEMODELINGMODE ▷ controls whether procedural or NURBS surfaces are created

◦ SURFACEASSOCIATIVITY ▷ controls whether surfaces maintain a relationship with the objects from which they were created

◦ SUBOBJSELECTIONMODE ▷ filters whether faces, edges, vertices or solid history subobjects are highlighted when you roll over them

Mesh Modelling

- MESH ▷ creates a 3D mesh primitive object (e.g. box, cone, cylinder, pyramid, sphere...)

◦ MESHPRIMITIVEOPTIONS ▷ set the tessellation defaults for primitive mesh objects

- MESHCAP ▷ creates a mesh face that connects open edges
- MESHCOLLAPSE ▷ merges the vertices of selected mesh faces or edges
- MESHCREASE • MESHUNCREASE ▷ sharpens the edges of selected mesh subobjects, or removes the crease from selected mesh faces, edges, or vertices
- MESHEXTRUDE ▷ extends mesh faces (singly or as a unit) into 3D space
- MESHMERGE • MESHSPLIT ▷ merges adjacent faces, or splits a face into two

- MESHREFINE ▷ multiplies the number of faces in selected mesh objects or faces
- MESHSMOOTHMORE • MESHSMOOTHLESS ▷ increases or decreases the level of smoothness for mesh objects by one level
- MESHSMOOTH ▷ converts objects (e.g. polygon meshes, surfaces, solids) to mesh objects
- ◦ MESHOPTIONS ▷ control the settings for converting existing objects to mesh objects

Conversion Commands

- CONVTOMESH ▷ converts 3D solids, 3D surfaces, legacy polyface and polygon meshes, 3D faces, regions, closed polylines to mesh objects
- CONVTONURBS ▷ converts 3D solids and procedural surfaces to NURBS surfaces
- CONVTOSURFACE ▷ converts solids, mesh objects, planar 3DFaces, regions, (open, zero-width) polylines, lines and arcs with thickness to smooth or faceted procedural surfaces
- CONVTOSOLID ▷ converts watertight meshes or surfaces to 3D solids
- THICKEN ▷ converts a surface into a 3D solid with a specified thickness
- SURFSCULPT ▷ trims and combines surfaces that bound a watertight area to create a solid
- ◦ SMOOTHMESHCONVERT ▷ when you convert a mesh, you can specify whether the converted objects are smoothed or faceted, and whether the faces are merged

2 Spire-polyhedra – Polyhedral Shapes in Architecture

A *gable* is a vertical plane (a wall) whose existence is inevitable whenever the bottom edges of the sloping surfaces of the roof proper are not horizontal. A *verge* is the sloping outer edge of a gable, a *gable apex* is the highest point of a verge. A *spire apex*, however, is a point located over the centre of the base, usually the highest point of the whole shape. A *valley* is a concave break between adjacent surfaces, which therefore collects the water from them; while a *ridge* is a convex break, which consequently diverts, not collects water. Finally, a *gable ridge* is a ridge starting from the gable apex, usually (but not always) connecting it with the spire apex.

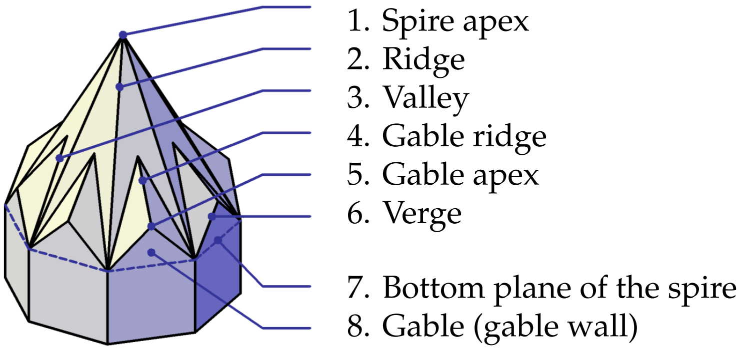


Figure 1: **Parts of a spire**

2.1 Basic Spire Shapes

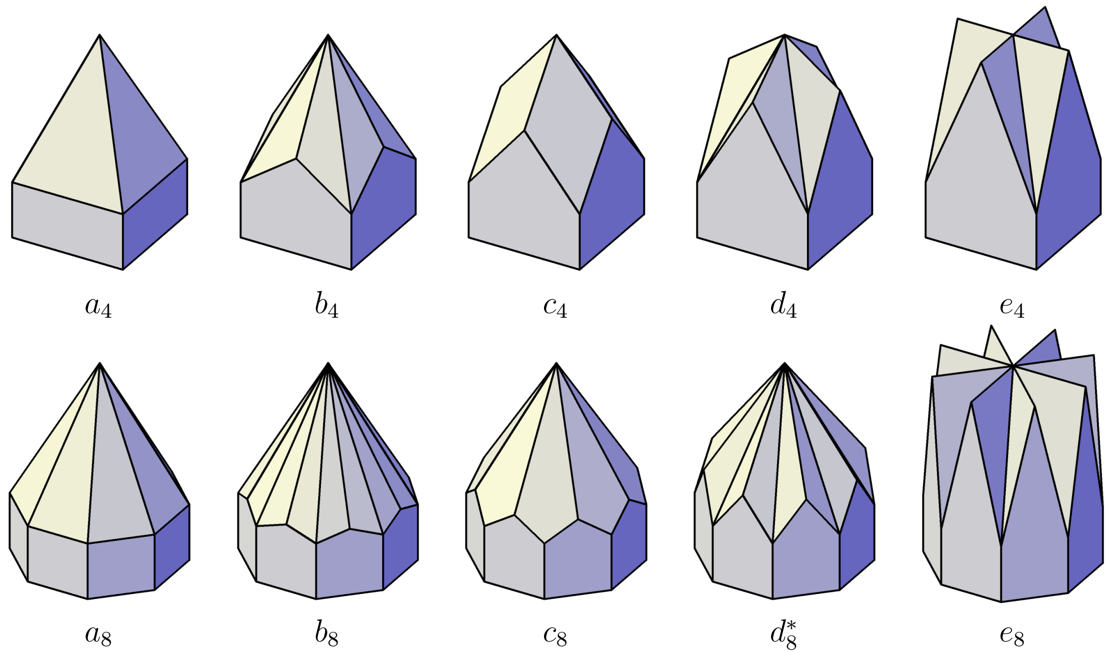
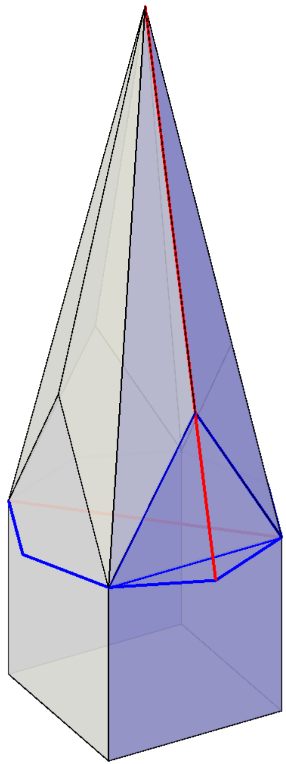
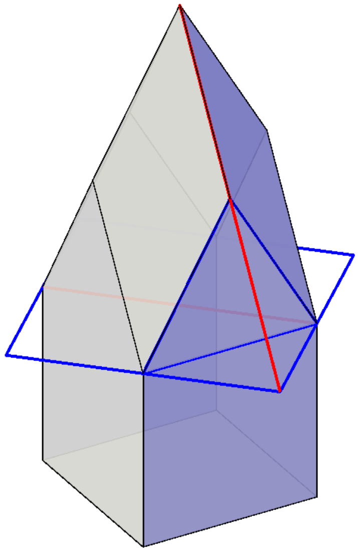


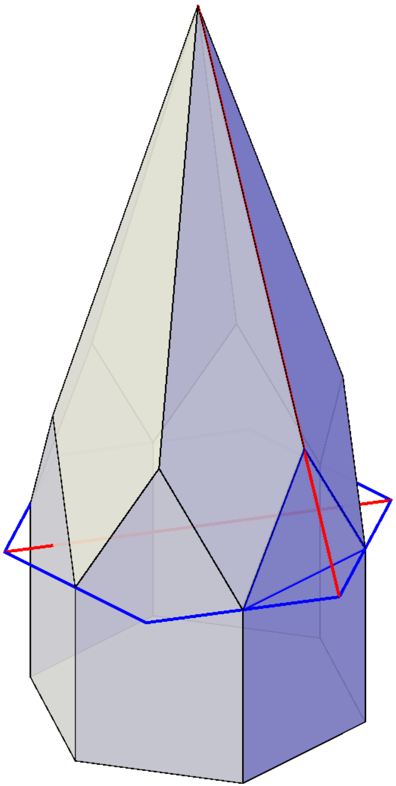
Figure 2: **Basic spire shapes, arranged in order of ascending gable apex height**: a_n regular n-gonal pyramid, b_n convex $2n$-gonal base-truncated pyramid, c_n rotated n-gonal base-truncated pyramid, d_n concave $2n$-gonal base-truncated pyramid, e_n intersecting gable roofs



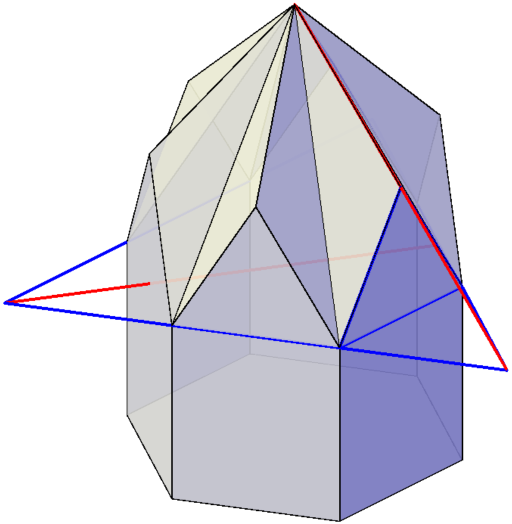
▷ b_4 SPIRE
convex $2n$-gonal
base-truncated
pyramid



▷ c_4 SPIRE
convex n-gonal
base-truncated
pyramid



▷ c_6 SPIRE
convex n-gonal
base-truncated
pyramid



▷ d_6 SPIRE
concave $2n$-gonal base-truncated pyramid

2.2 Compound Spire Shapes

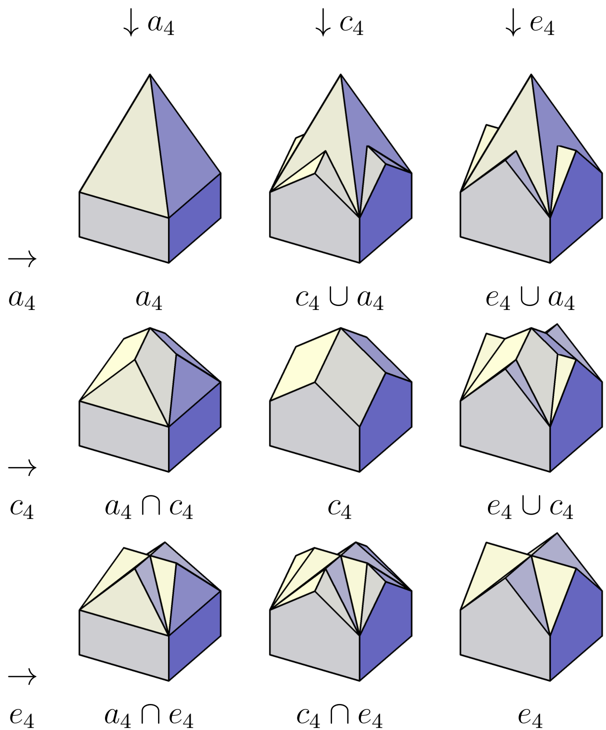
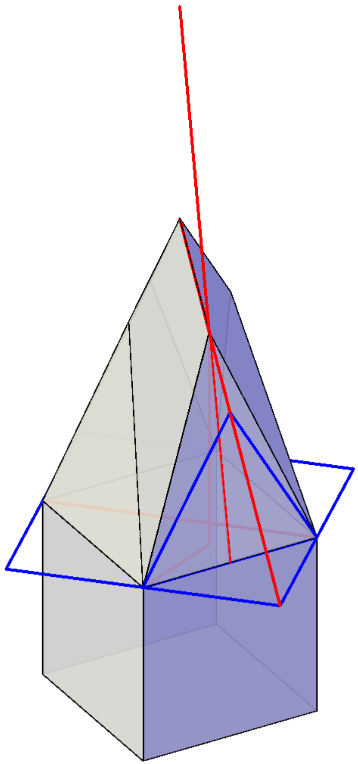
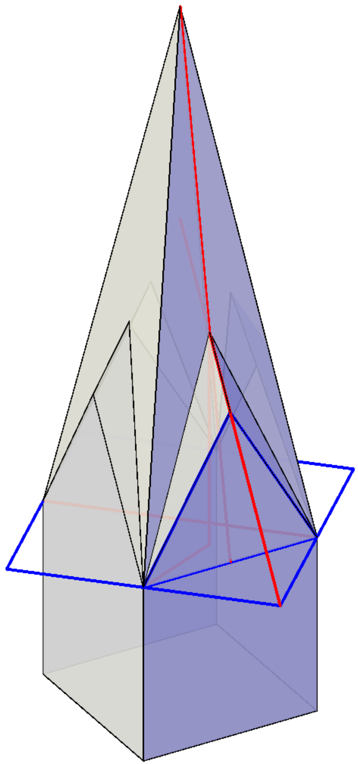


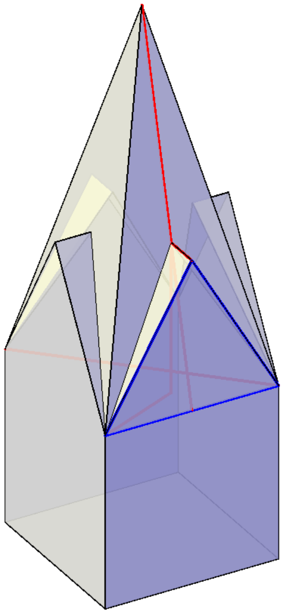
Figure 3: **Combinations of basic shapes having square base**



$\triangleright$ $a_4 \cap c_4$ SPIRE

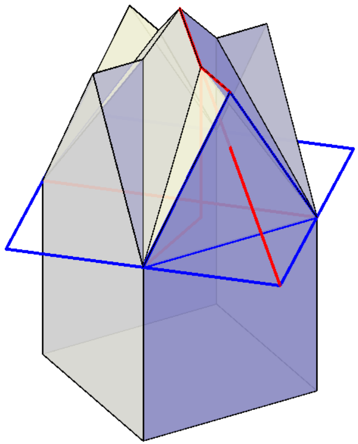


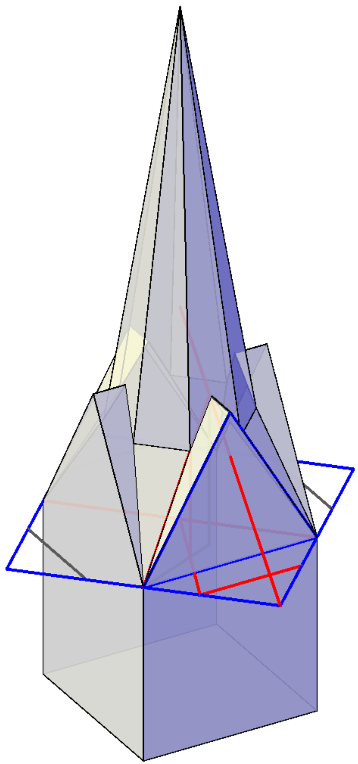
$\triangleright$ $c_4 \cup a_4$ SPIRE



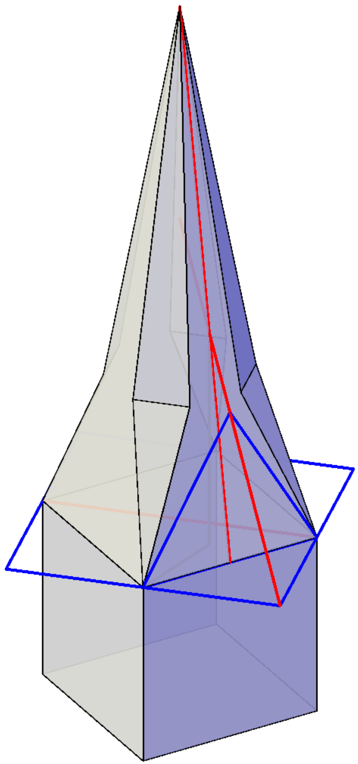
$\triangleright$ $e_4 \cup a_4$ SPIRE

$\triangleright$ $e_4 \cup c_4$ SPIRE

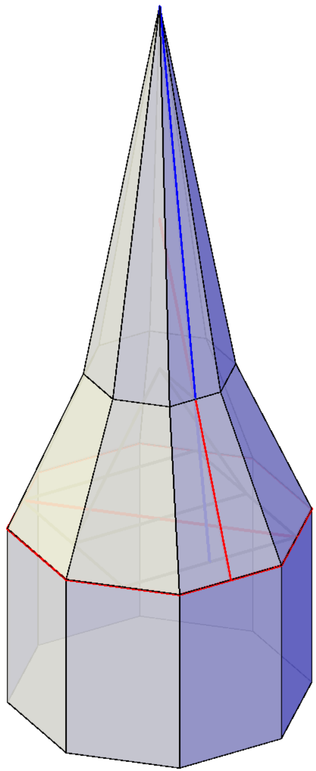




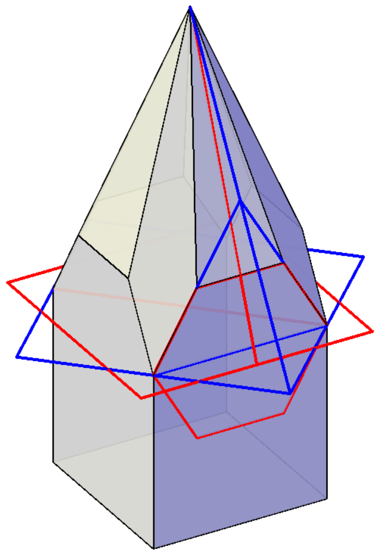
$\triangleright\ e_4 \cup c_4 \cup a_8$ SPIRE



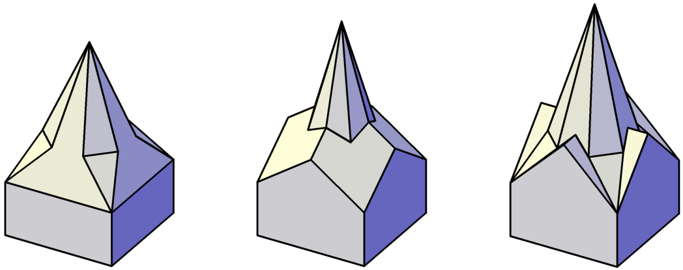
$\triangleright$ $a_4 \cap c_4 \cup a_8$ SPIRE



$\triangleright$ $a_8 \cup a_8'$ SPIRE

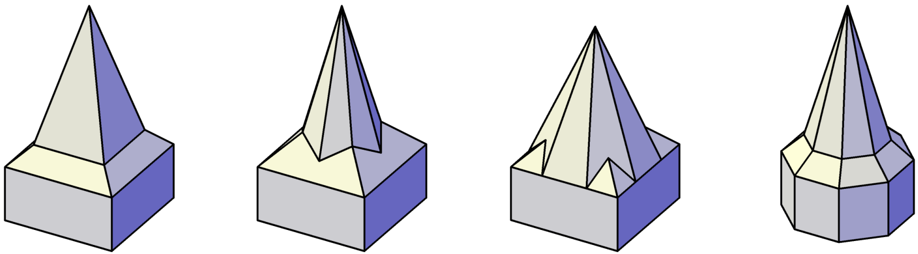


$\triangleright$ $c_4 \cap a'_4$ SPIRE



$a_4 \cap c_4 \cup a_8$ $c_4 \cup a_8'^r$ $e_4 \cup c_4 \cup a_8$

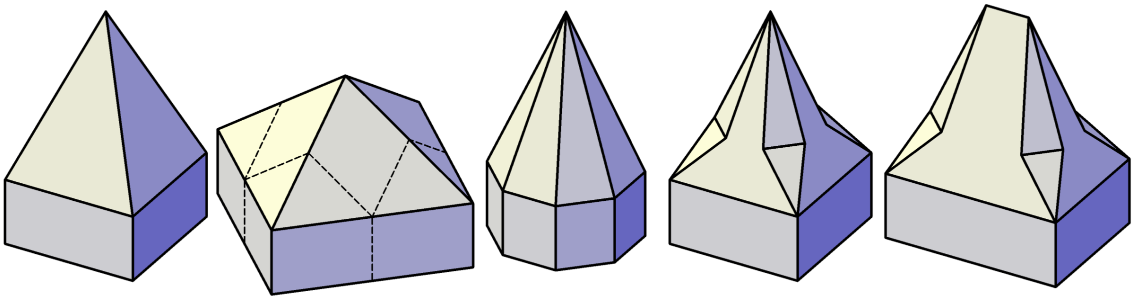
Figure 4: **The shapes of the second row of Figure 3 with an added a_8 pyramid**



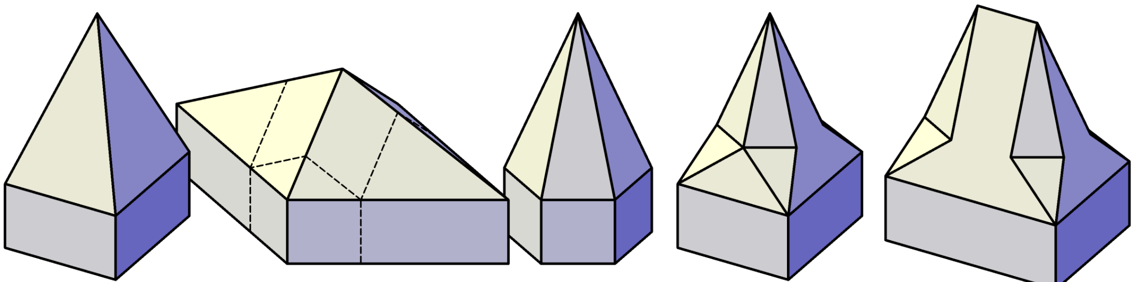
$a_4 \cup a_4'$ $a_4 \cup a_8'^r$ $a_4 \cup a_8$ $a_8 \cup a_8'$

Figure 5: **Unions of a_n pyramids**

2.3 Rectangular Base



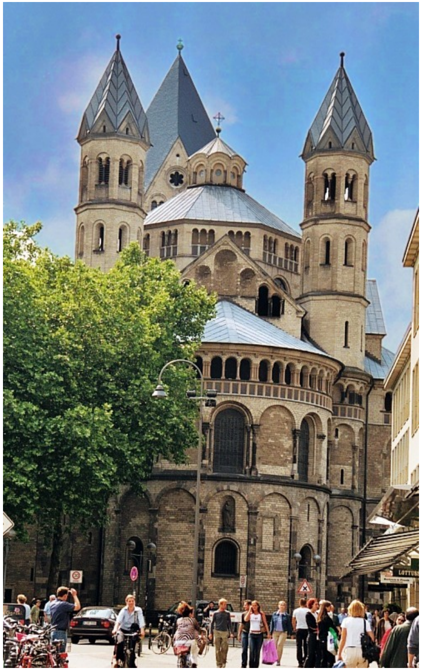
a_4, a_4^r (or c_4), and a_8 base shapes, their $a_4 \cap c_4 \cup a_8$ compound, and its extrusion



a_4^δ, a_4^ρ, and a_6 base shapes, their $a_4^\delta \cap a_4^\rho \cup a_6$ compound, and its extrusion

Figure 6: **Covering a rectangular base** – different elements, similar results

Examples



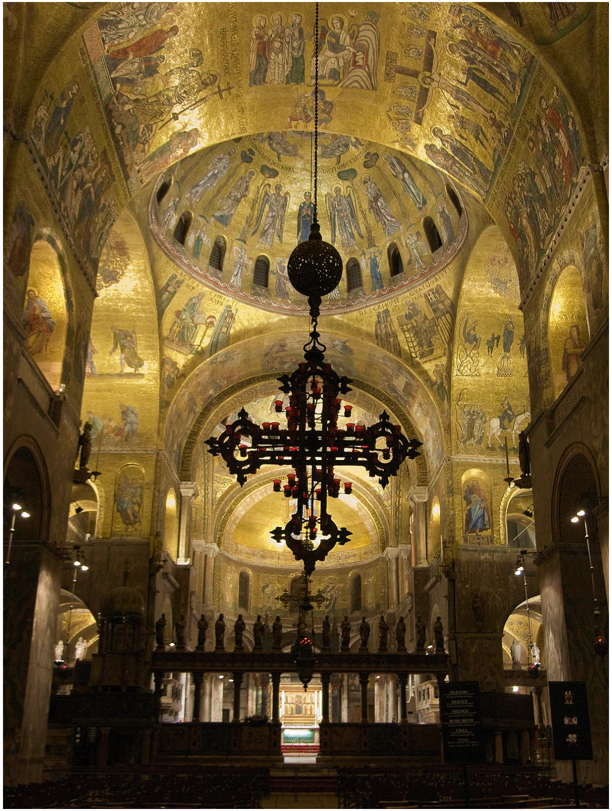
Cologne, St. Aposteln

Bonn, St. Martin Münster

Lübeck, Marienkirche

Figure 7: **Examples of spires**

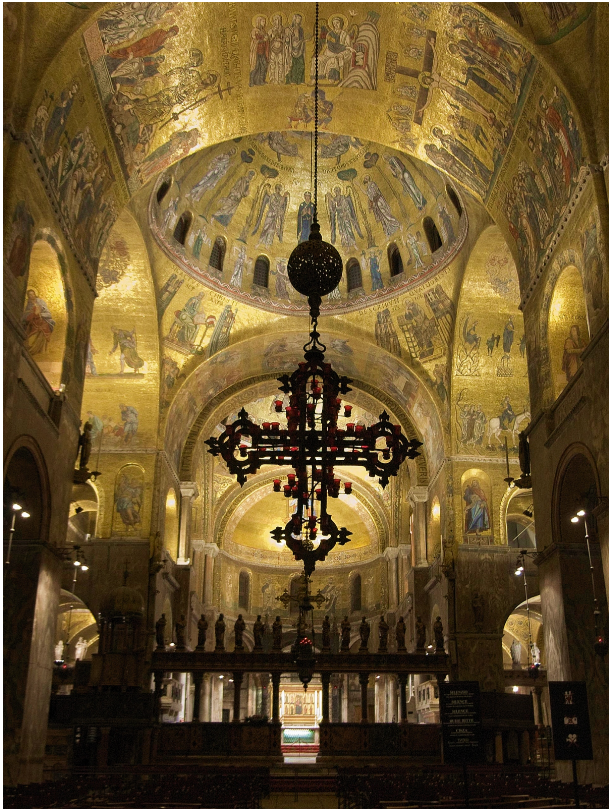
3 Vault Morphology – Curved Shapes in Architecture



The Nave of San Marco

Spandrelized Definitions

In their paper, *"The Spandrels of San Marco and the Panglossian Paradigm"* **Gould** and **Lewontin** introduced a new term *spandrel*, as an alternative process in evolution to adaptation [Gould – Lewontin, 1979].
They claimed that in the San Marco Cathedral in Venice the mosaic design was so "harmonious and purposeful", that one might think that this design was the cause of the architecture surrounding it.
But in reality, the system began with the architectural constraint, since the spandrels (the tapering triangular spaces formed by the intersection of two rounded arches at right angle) were necessary architectural by-products of mounting a dome on rounded arches.
The same way, they said, it was possible that some attributes of living beings did not evolve as an adaptation (with the "mosaic" as the driving force behind them), but they appeared as unforeseen by-products of hidden constraints—in other words they had been "spandrelized".



The Nave of San Marco

Daniel C. Dennett in his book *"Darwin's Dangerous Idea"* [Dennett, 1998] highly disagreed with this chain of thought. He pointed out that the term "spandrel" had been used in two different meanings.
Strictly speaking, the tapering surfaces in San Marco are *pendentives*, not spandrels. But if by "spandrel" the authors meant pendentive, the above analogy is simply inappropriate, since the usage of pendentive was not an unavoidable necessity—it was only one of the possible solutions.
In a looser sense however, a pendentive (among other shapes) can also be called (as one type of) spandrel—but in this case the statement is practically meaningless, since if the definition of a spandrel is that it is a space between two neighbouring arches, then the observation, that there is a spandrel between every two arches can hardly be seen as a revelation.
Thus, the pendentive can be called spandrel in art history, but, according to Dennett, it cannot be called "spandrel"—the latter being the mysterious rival process of adaptation in evolution.

The previous example raises another question. Dennett pointed out that spandrel is too loose of a term to specify an exact geometry—but he obviously thought that the term pendentive is a geometrically unambiguous definition.

According to the common definition a pendentive is “*one of the triangular segments of the lower part of a hemispherical dome, used to effect a transition at the angles from a square or polygonal base below to a a circle above, on which a complete dome may rest*” [Fitchen, 1961]. But similar shapes can be derived from different logic—and sometimes it’s not easy to distinguish them from a spherical shape.

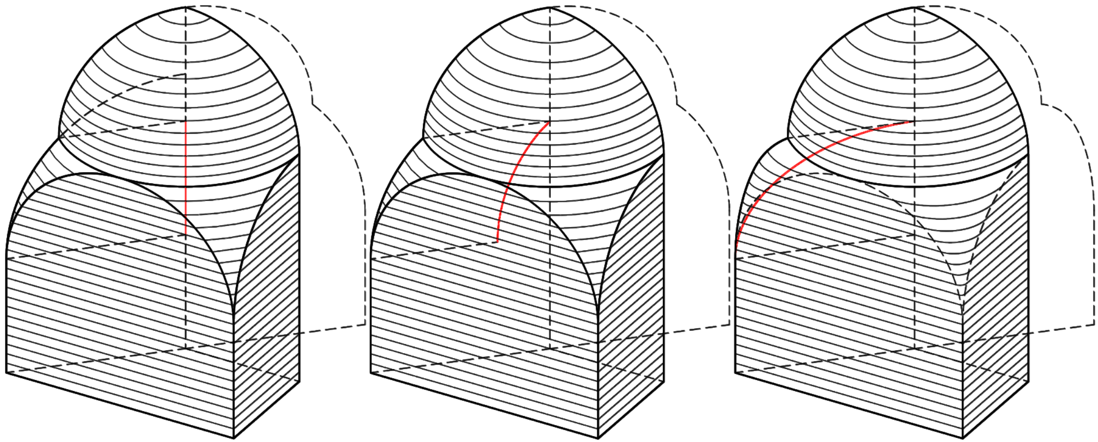


Figure 8: **Alternative Pendentive-forms**

Geometry of Vaults

Barrel Vaults and Domes

The two most obvious ways of transforming the two-dimensional arch into a three-dimensional shape are extrusion and revolution.

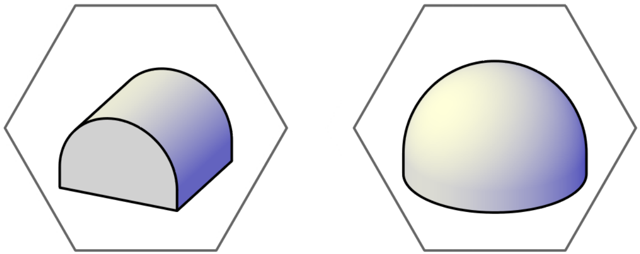


Figure 9: **Barrel vault and dome**

Cloister Vault and Cross Vault

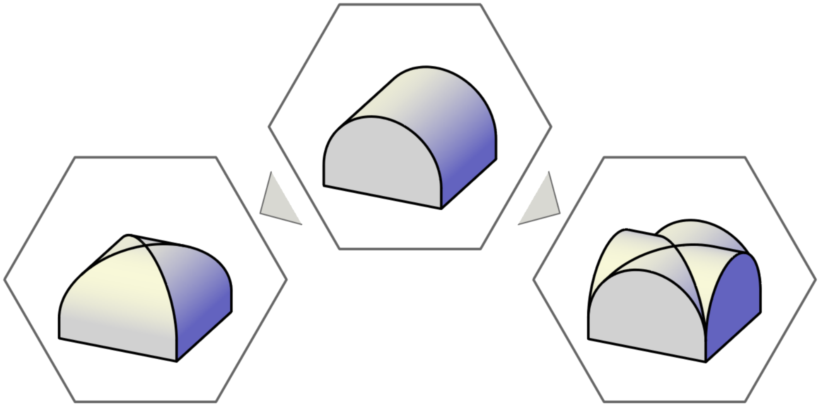
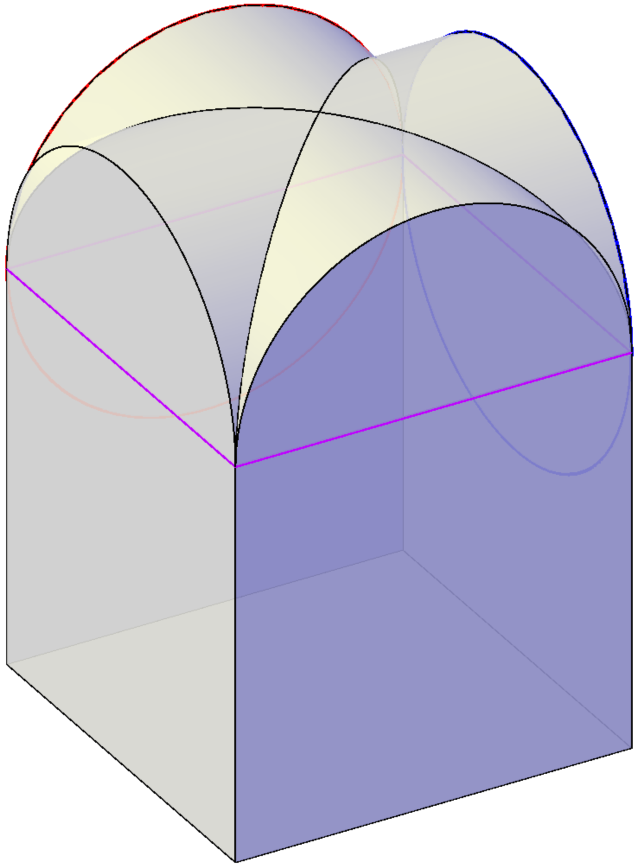
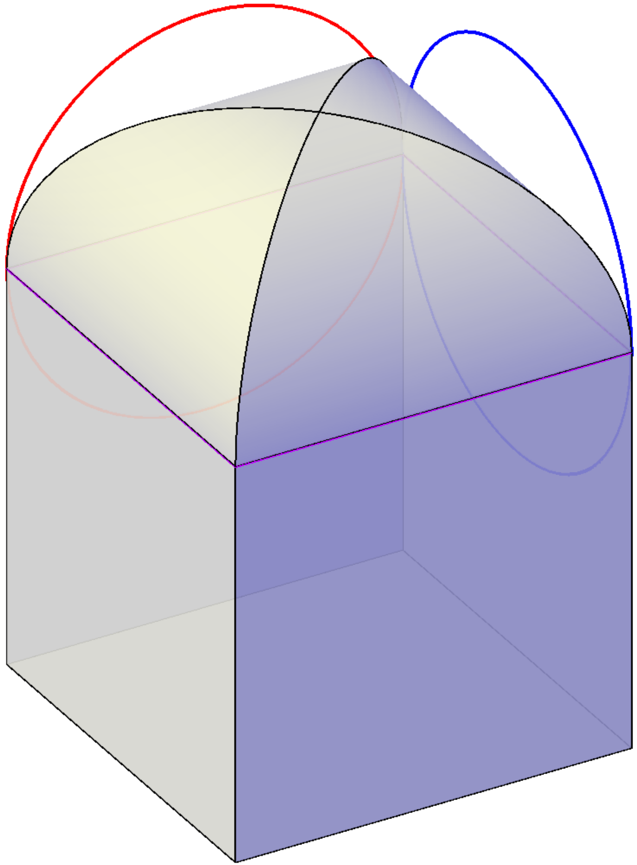


Figure 10: **Intersection (∩) and union (∪) of two barrel vaults meeting at a right angle**

- As it can be seen in Figure 10 the horizontal sections of a cloister vault are convex shapes, whereas the horizontal sections of a cross vault are concave shapes. Based on these attributes, we can classify the vault shapes as **convex or concave vaults**.



▷ Cross Vault



▷ Cloister Vault

Poligonal Domes

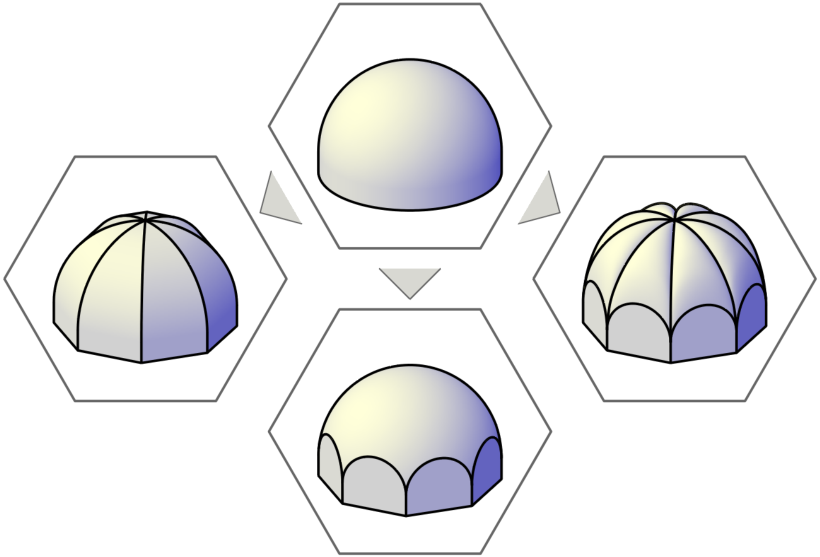
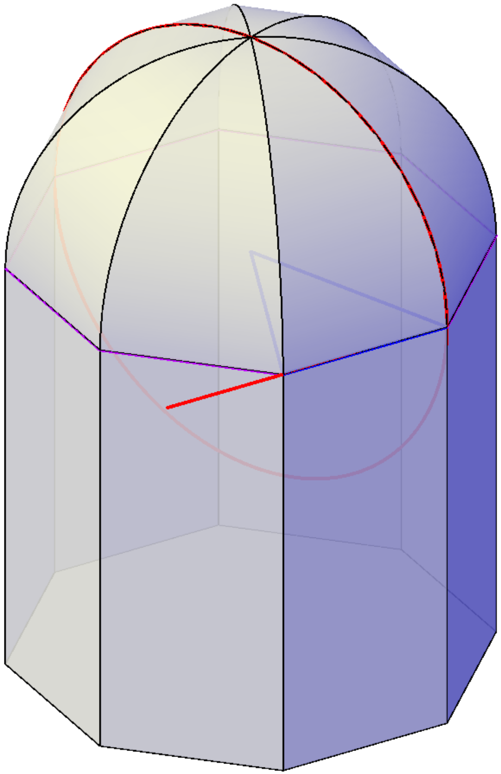
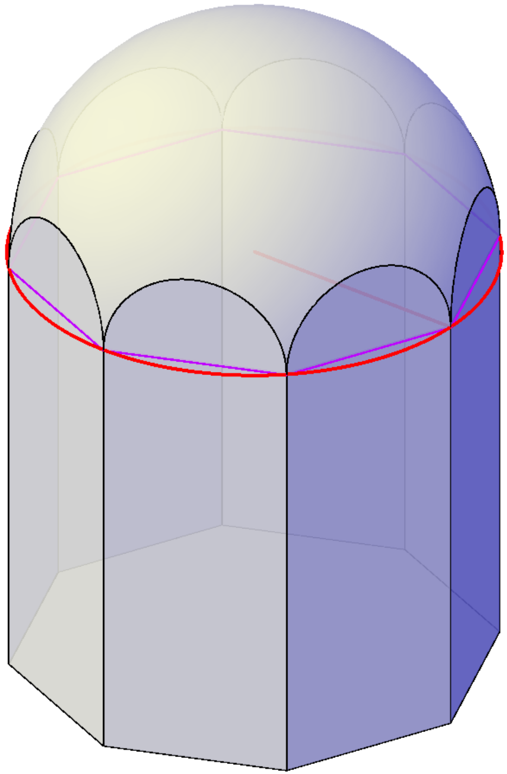


Figure 11: **Heightened cloister vault, sail vault, and melon (parachute) dome**



▷ Cloister Vault



▷ SAIL VAULT

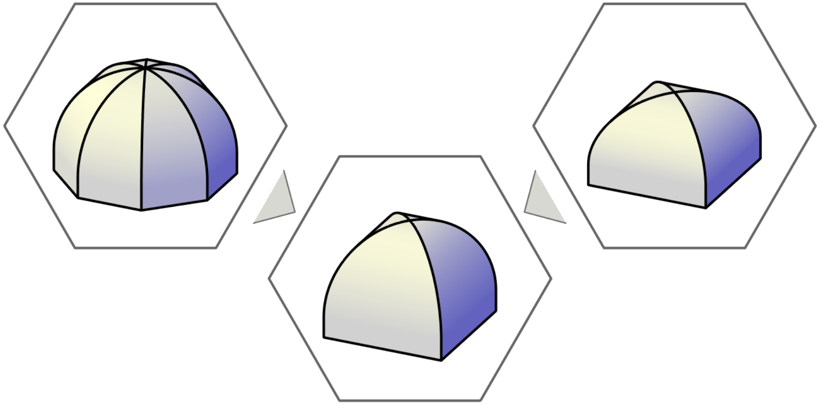
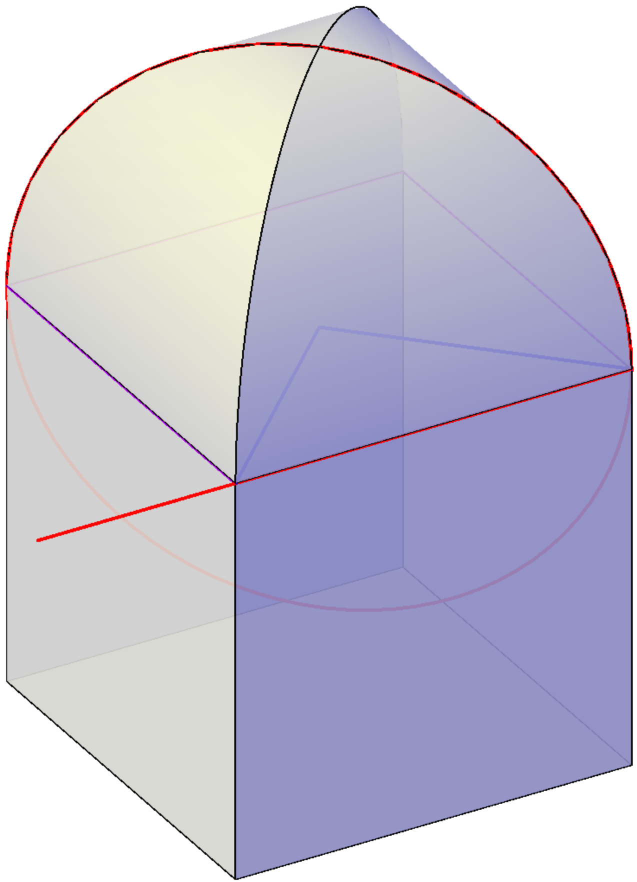


Figure 12: **Heightened cloister vault over square base**



▷ Cloister Vault

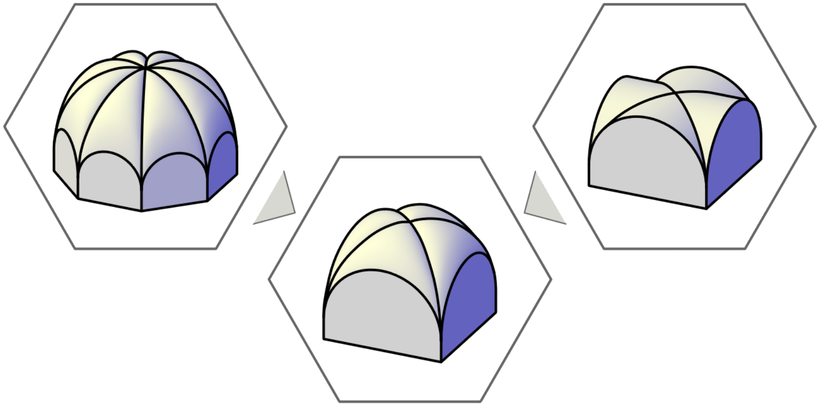


Figure 13: **Heightened cross vault over square base**

3.1 Morphological Map of Vaults

The network of the geometrical and logical relations of vault shapes can be graphically depicted as a “morphological map”. By adapting the principle of Occam’s razor for this map it can be assumed that new vault shapes were most likely to be developed from one of their neighbours.

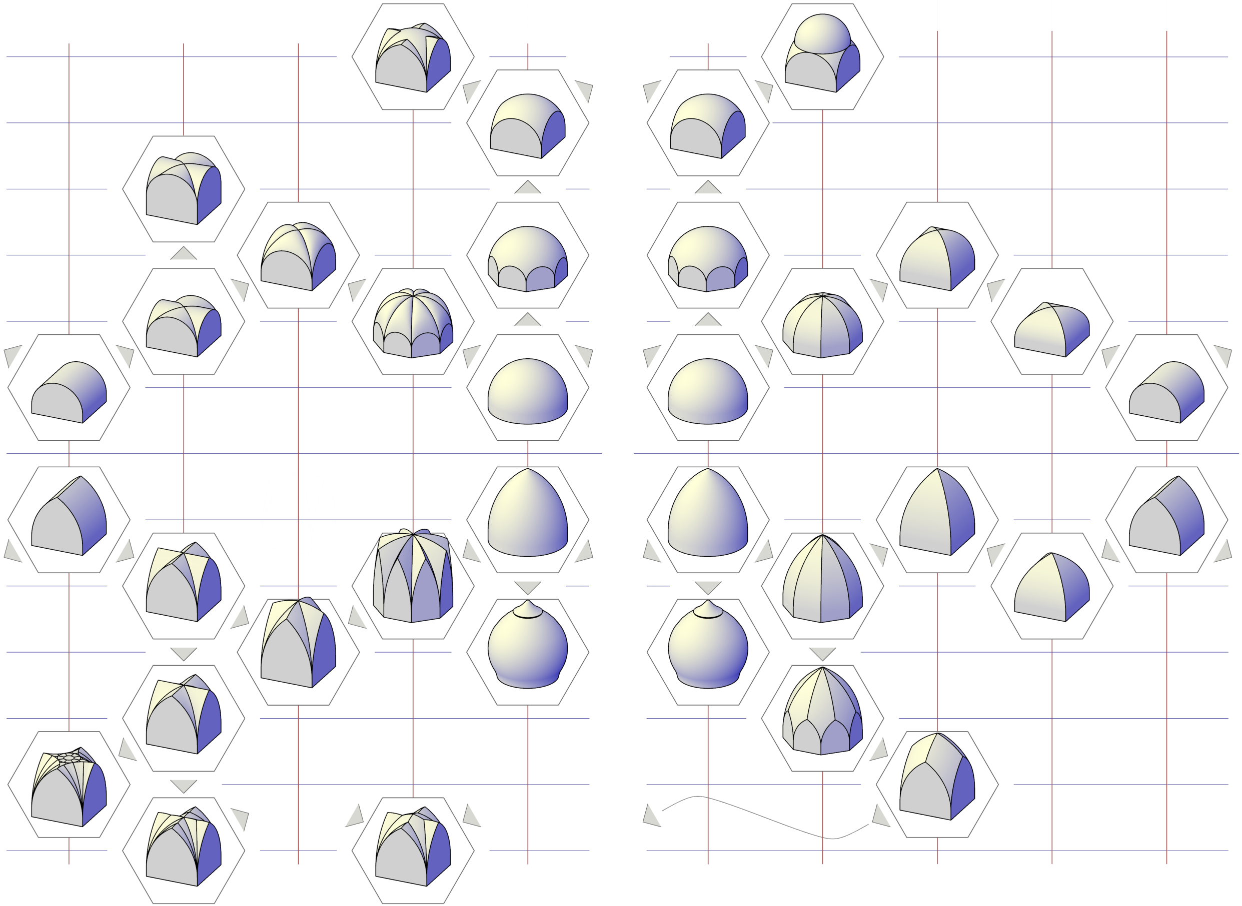


Figure 14: **Morphological Map of Vaults**

Domes

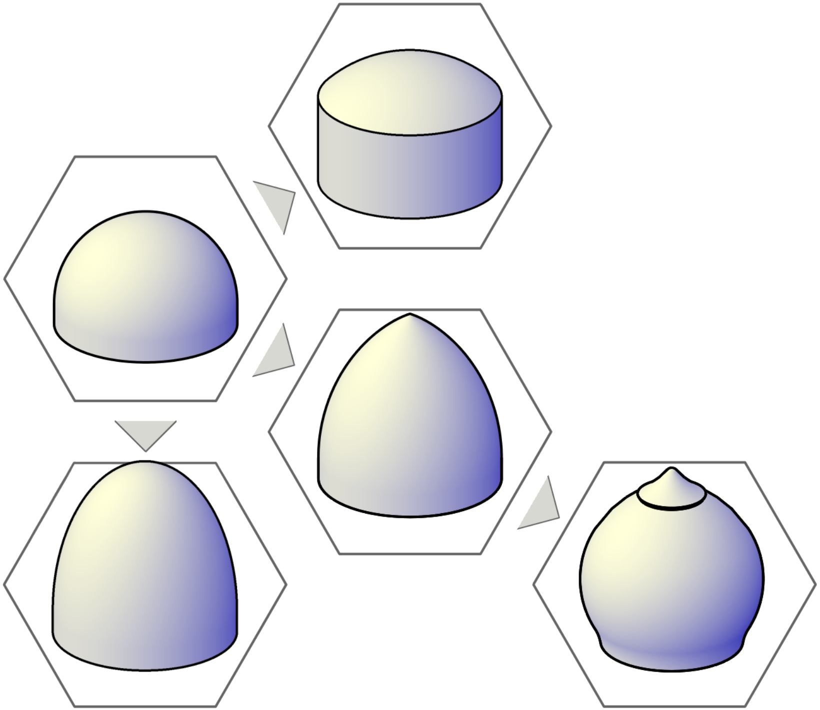
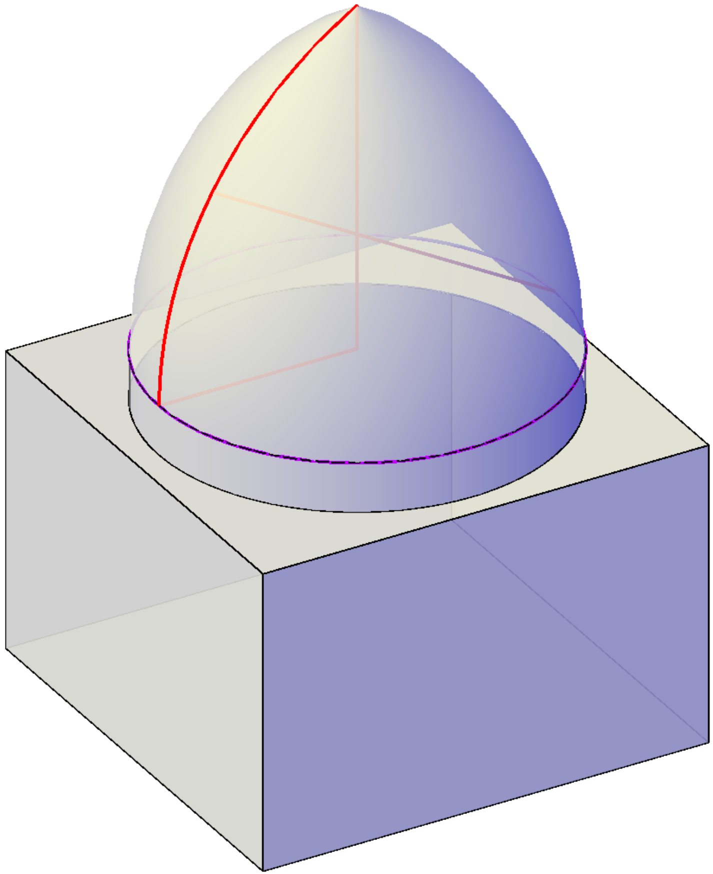


Figure 15: **Dome shapes**



▷ Pointed Dome

Pendentives

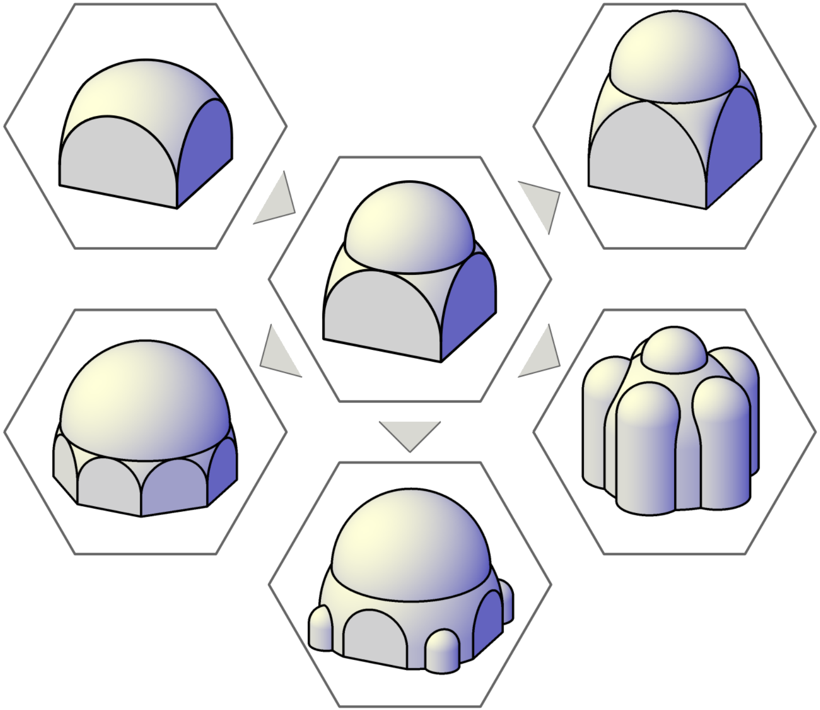
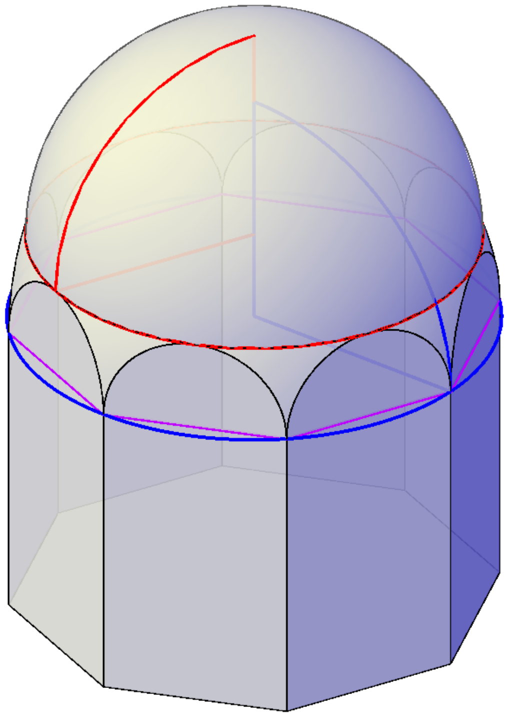
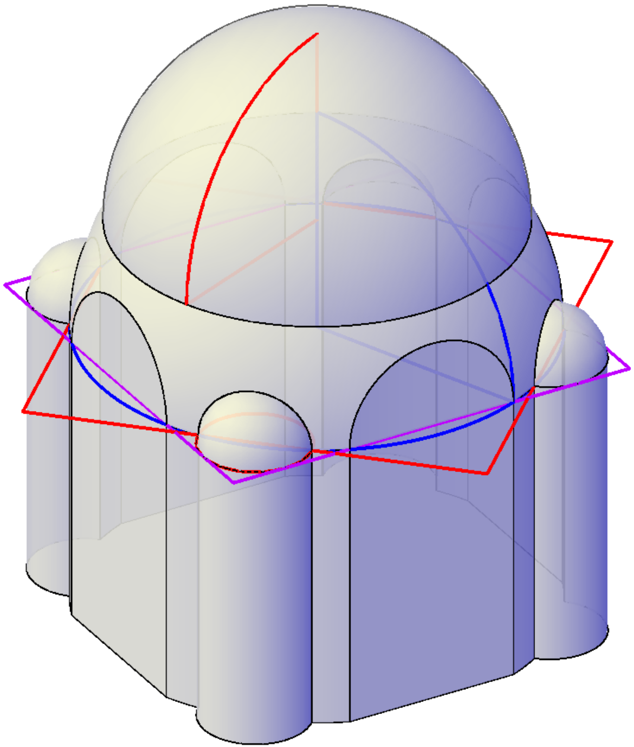


Figure 16: **Pendentive-variants**



▷ DOME ON PENDENTIVES
Theoretical Scheme



▷ Dome on Pendentives
With Corner Niches

Truncated Spheres

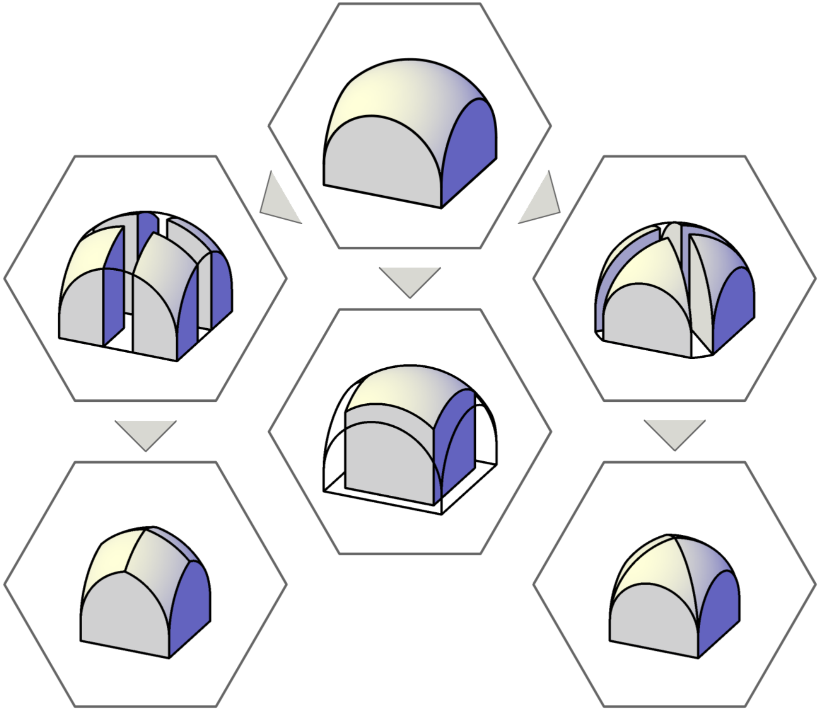
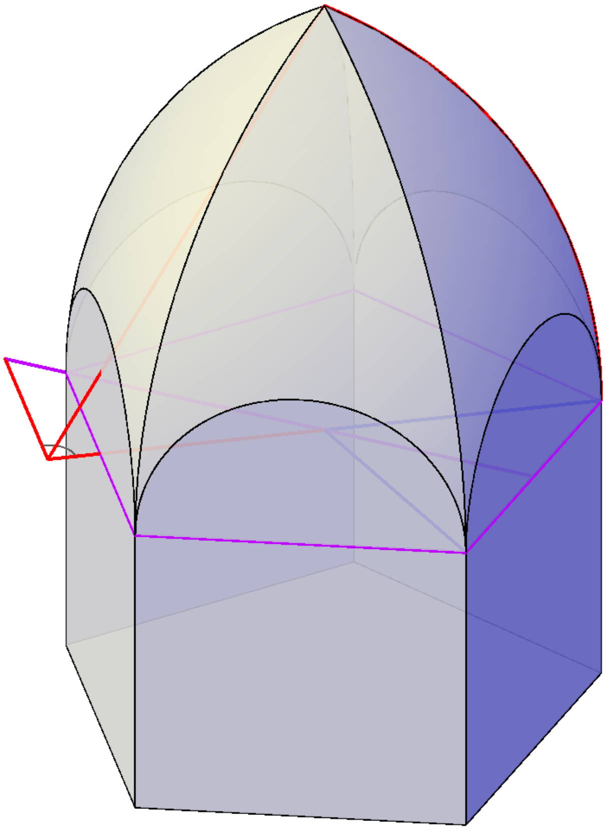
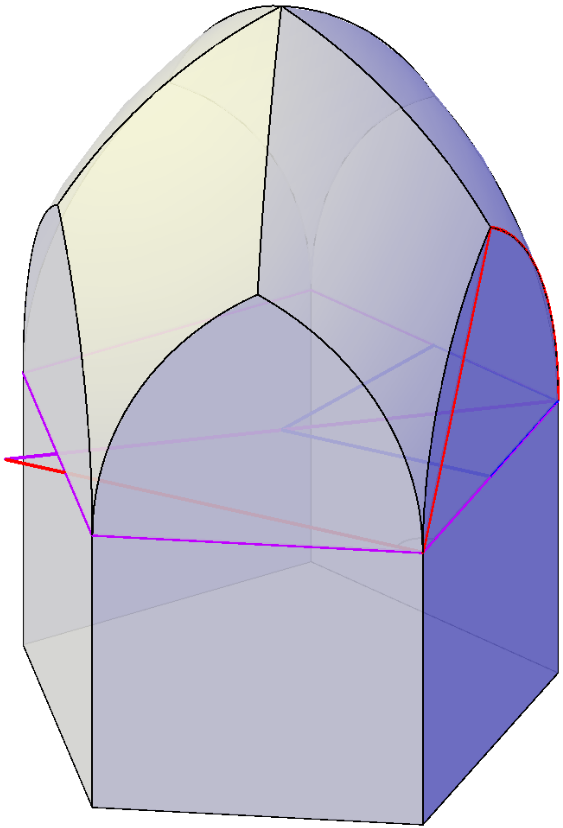


Figure 17: **Truncated spheres**



▷ DOMICAL VAULT
With Pointed Diagonal Arches



▷ Domical Vault
Without Diagonal Arches

Relationships

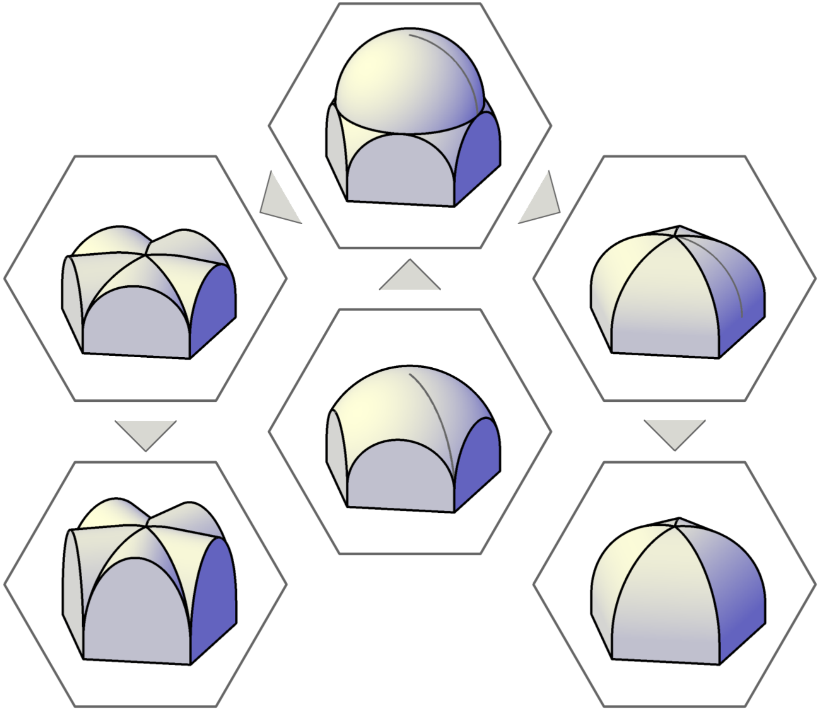


Figure 18: **Dome on pendentives, sail vault, cross vault, cloister vault**

Rib Vaults

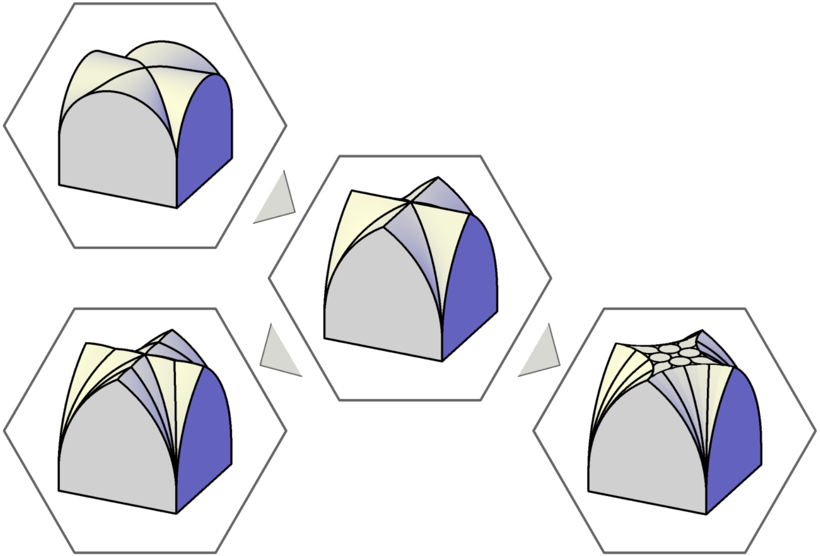
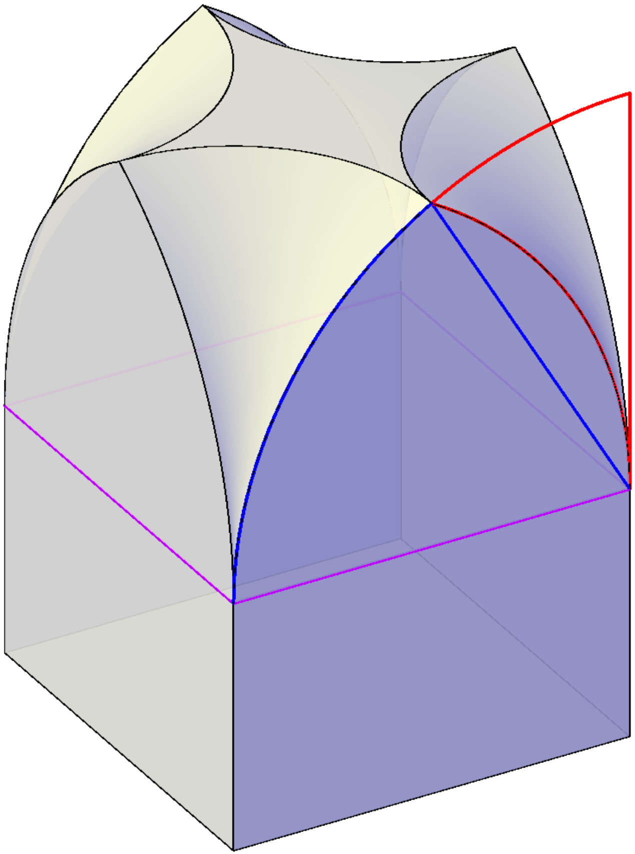
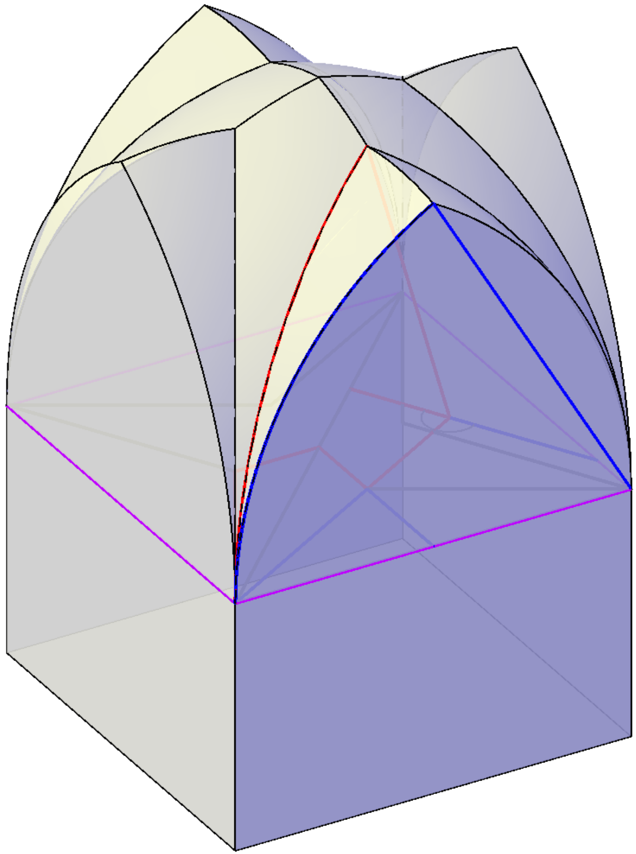


Figure 19: **English rib vaults—tierceron vault, fan vault**



▷ FAN VAULT
Theoretical Scheme



▷ Simple Star Vault
Theoretical Scheme

4 Views, Lighting, Materials, Rendering

- UNITS ▷ specifies the unit of measurement (length, angle, intensity of lights)
- -VPORTS ▷ creates a layout viewport with a specific aspect ratio
- CAMERA ▷ sets a camera in order to define a 3D view
- VIEW ▷ saves and restores named views and camera views
- VSCURRENT ▷ sets the visual style in the current viewport – a visual style is a collection of customizable settings that control the display of edges, faces, background and shadows
- VISUALSTYLES ▷ creates and modifies visual styles and applies a visual style to a viewport
- TOOLPALETTES ▷ visual styles can be copied between drawings using the Visual Styles tab
- 3DCONFIG ▷ control the appearance through the *Manual Performance Tuning* panel

Lighting

- DISTANTLIGHT ▷ creates a distant light (without attenuation)
- POINTLIGHT ▷ creates a point light that radiates light in all directions from its location
- SPOTLIGHT ▷ creates a spotlight that emits a directional cone of light from its location

- DEFAULTLIGHTING ▷ toggles default lighting (instead of other lighting) viewport-specifically
- SUNPROPERTIES ▷ provides different panels to specify sun and sky settings and controls
- GEOGRAPHICLOCATION ▷ specifies the geographic location information for a drawing file
  sets the location using the *Geographic Location* panel
  or imports a .kml or a .kmz file, or the current location from *Google Earth*
- TOOLPALETTES ▷ provides additional realistic (and generic) lights

◦ LIGHTINGUNITS ▷ controls whether generic or photometric lights are used, and specifies the (American or International) lighting units for the drawing
  0 ▷ no lighting units are used and standard (generic) lighting is enabled
  2 ▷ international lighting units (lux) are used and photometric lighting is enabled

Materials

- MATBROWSEROPEN ▷ opens the *Materials Browser* in order to manage the materials
- MATEDITOROPEN ▷ opens the *Materials Editor* in order to edit a selected material
- MATERIALATTACH ▷ associates materials with layers
- MATERIALMAP ▷ displays a gizmo to adjust the material mapping on a face or an object (sets planar, box, cylindrical, spherical mapping, copies or resets position and orientation)

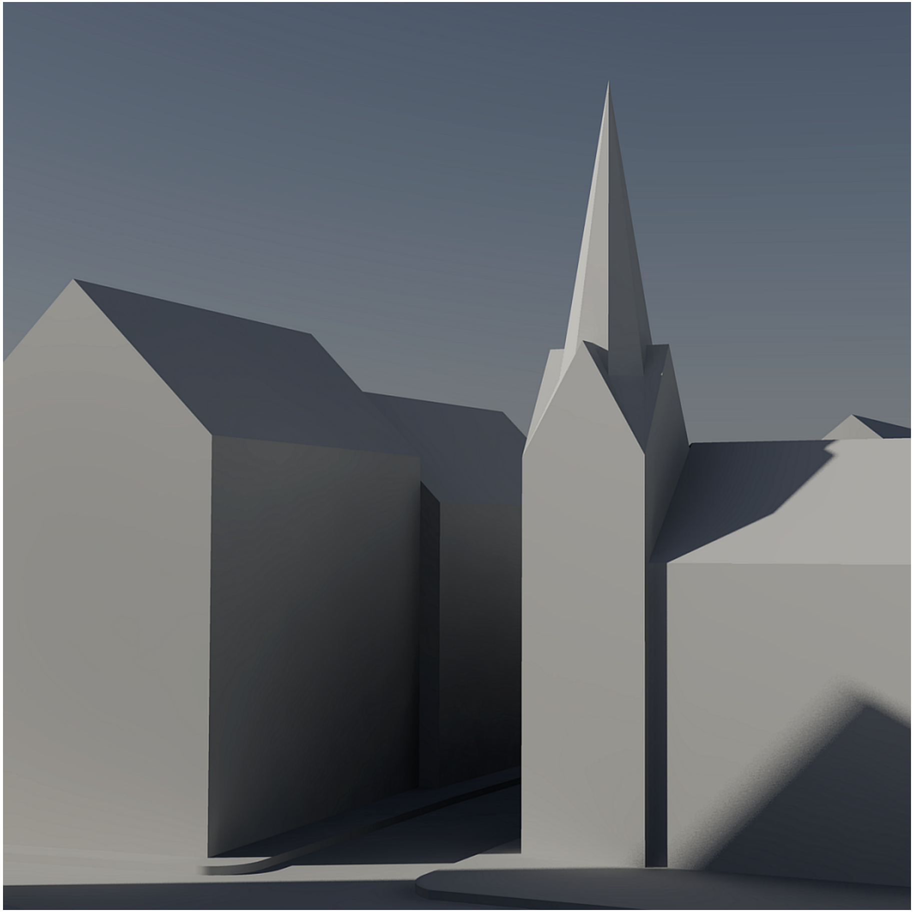
◦ CMATERIAL ▷ sets the material of new objects (BYLAYER, BYBLOCK, or a material-name)

Creating New Textures

- MANAGING OBJECTS ▷ setting the canvas size, duplicating, arranging, combining objects
- CONTINUOUS TEXTURE ▷ using the CLONE (C) or the FREEHAND MASK (K) tools

Rendering

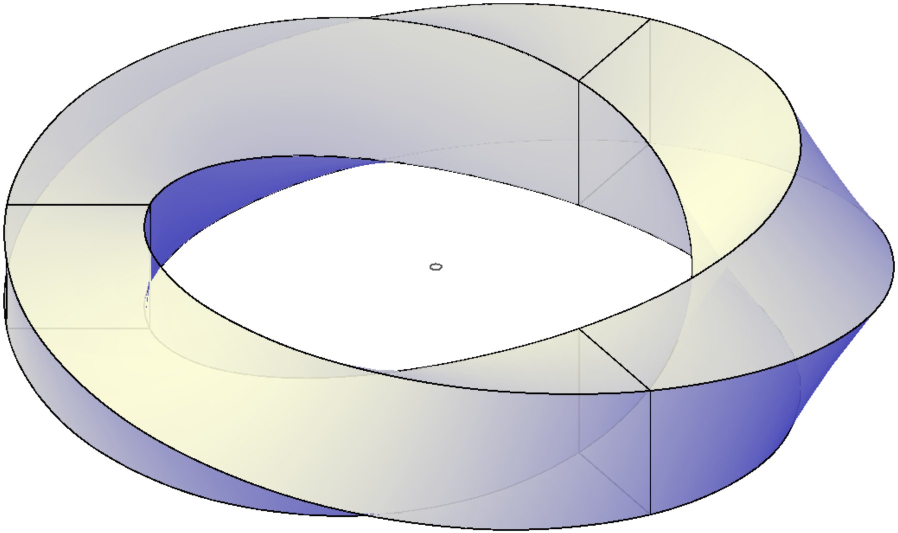
- RPREF ▷ displays or hides the *Advanced Render Settings* palette (e.g. quality, size)
- ◦ VIEWRES ▷ sets the resolution for circles, arcs, splines, and arced polylines
- ◦ SPLINESEGS ▷ sets the number of line segments to be generated for each spline-fit polyline
- ◦ FACETRES ▷ sets the smoothness of shaded objects and objects with hidden lines removed
- ◦ ISOLINES ▷ specifies the number of contour lines per surface on objects
- ◦ DISPSILH ▷ toggles the display of silhouette edges of 3D solid objects
  1 ▷ also suppresses the mesh displayed when using the HIDE command



▷ RENDERING
With Sky Background,
Without Textures

5 Scripting

- AUTOCAD SCRIPTS ▷ simplifying tedious repetitive tasks without programming
- PARAMETRIC SCRIPTS ▷ using a spreadsheet for setting or calculating parameters



▷ MOEBIUS RING

```
_EXPERT 0 SORTENTS 127 -OSNAP _ins -Color _ByLayer
_PLAN _C _Zoom -400,-200 400,600
_-Layer _Make SQUARE

_Rectang -40,-40 40,40
_-Layer _New Moebius

_-Block SQUARE
0,0 _L
_-Insert SQUARE
0,0 1 1 0
_UCS _OBject _L _UCS O 0,200
_Rotate3d _L _None 0,0 _None 0,200 90
_Copy _L 0,0 _ROtate _L 0,0 24 _UCS _OBject _L _ROtate _L 0,0 18 _UCS _P
_Copy _L 0,0 _ROtate _L 0,0 24 _UCS _OBject _L _ROtate _L 0,0 18 _UCS _P
...
_Copy _L 0,0 _ROtate _L 0,0 24 _UCS _OBject _L _ROtate _L 0,0 18 _UCS _P
_Copy _L 0,0 _ROtate _L 0,0 24 _UCS _OBject _L _ROtate _L 0,0 18 _UCS _P
_UCS _P _UCS _P _Zoom _Previous _Zoom _Previous
_VPoint _Rotate 240 30 _Zoom _Extent
```

6 HTML Basics

▷ STRUCTURE

```
<HTML>
<HEAD>
<TITLE>Page Title</TITLE>
</HEAD>

<BODY>
<H1>HEADING 1</H1>
<P>Paragraph text<BR>
with line break.</P>
</BODY>
</HTML>
```

▷ LINKS

```
<A href="filename.ext" title="...">...</A>
```

▷ THUMBNAILS

```
<IMG src="..." title="..." alt="..." width="x" height="y" align="...">
```

• VALIDATING

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<A href="http://validator.w3.org/check?uri=referer">...</A>
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