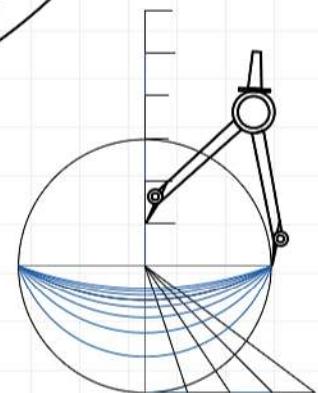
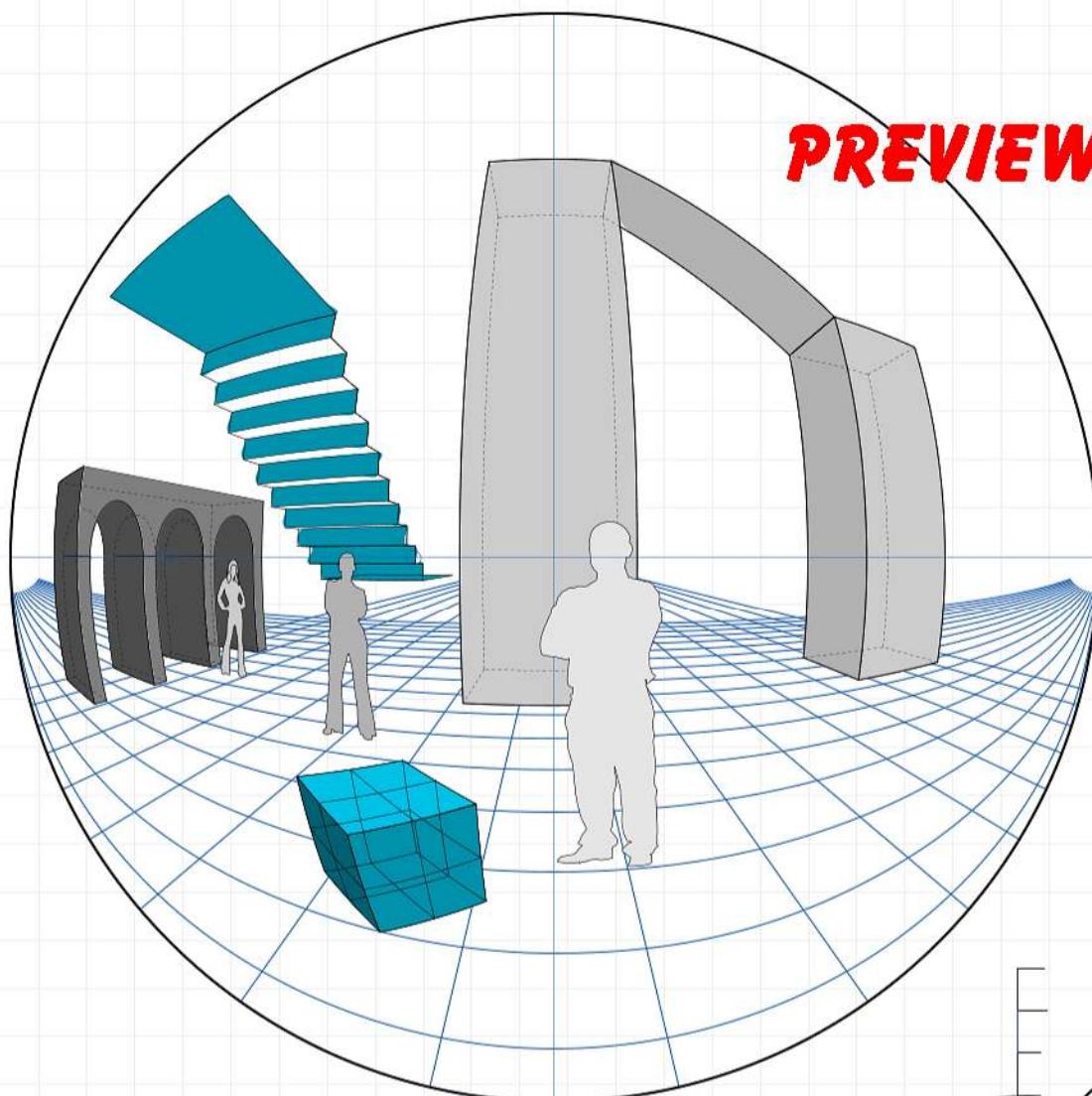


HOW TO DRAW CURVILINEAR PERSPECTIVE

4 - 5 - 6 VANISHING POINTS



Massimo N. Marrazzo

Massimo Nicola Marrazzo

How to draw curvilinear perspective

4 - 5 - 6 vanishing points



Terminologia



Terminology



Términos



Termes employés



Fachbegriffe

How to draw curvilinear perspective

4 - 5 - 6 vanishing points

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First edition: August 2018

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Dominique Raynaud - https://www.researchgate.net/profile/Dominique_Raynaud
Sascha Grusche - https://www.researchgate.net/profile/Sascha_Grusche

Credits

page 4	piazza del campo.skp	https://3dwarehouse.sketchup.com
page 9	vaisseau-06.skp	https://3dwarehouse.sketchup.com
page 9	large city.skp	https://3dwarehouse.sketchup.com
page 12, 20, 51, 59	furniture models	http://www.sweethome3d.com
page 23, 53, 54, 56, 58, 67	character models Reallusion	https://www.reallusion.com

ABBREVIATIONS AND SYMBOLS

⊕ CV= Center of Vision

D= Distance from Picture Plane

GL= Ground Line

GP= Ground Plane

H= Height point of view (eyes level)

HL= Horizon Line

▼ IMP= Left Measuring Point

⊖ IVP= Left Vanishing Point

MP= Measuring Point

Os= Observer

PP= Picture Plane

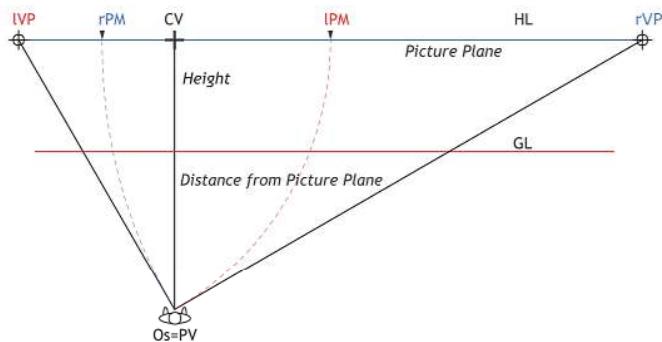
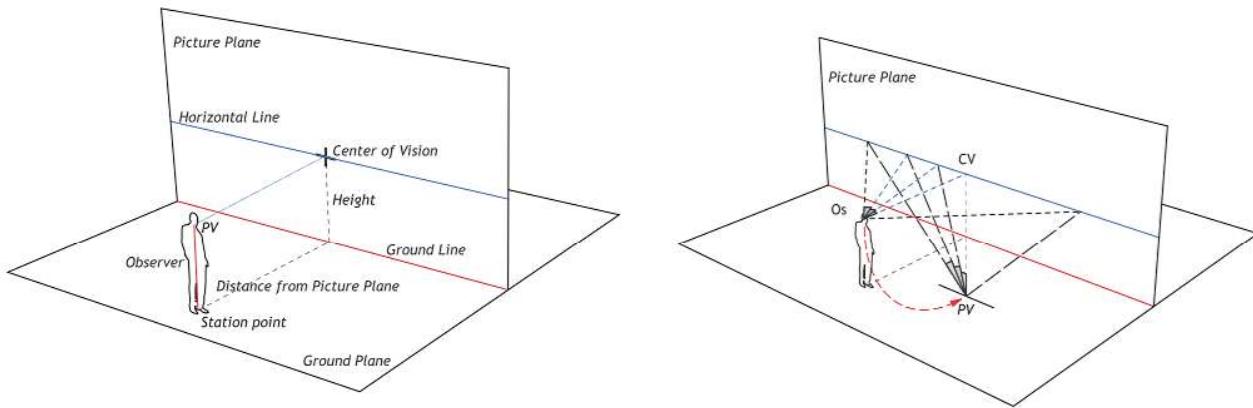
PS= Point of Station

PV= Point of View

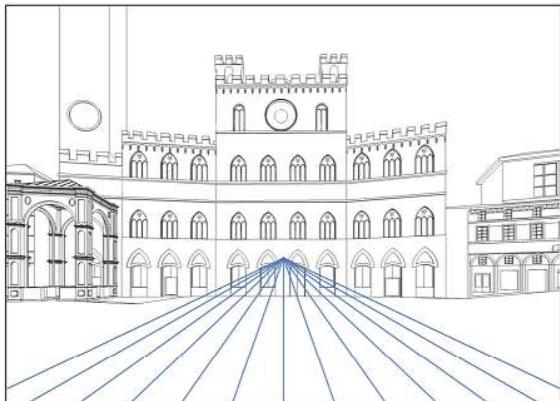
▼ rMP= Right Measuring Point

⊖ rVP= Right Vanishing Point

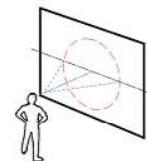
VL= Vanishing Line



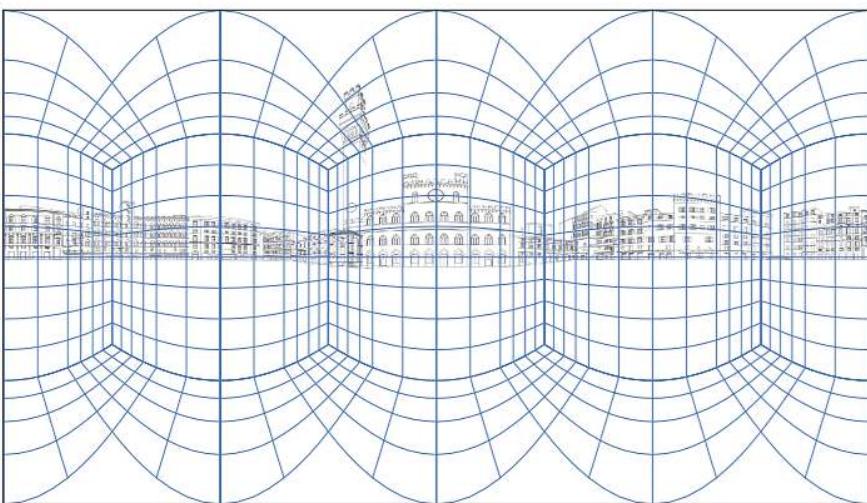
INTRODUCTION



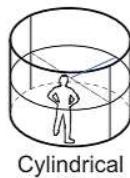
One-point Perspective



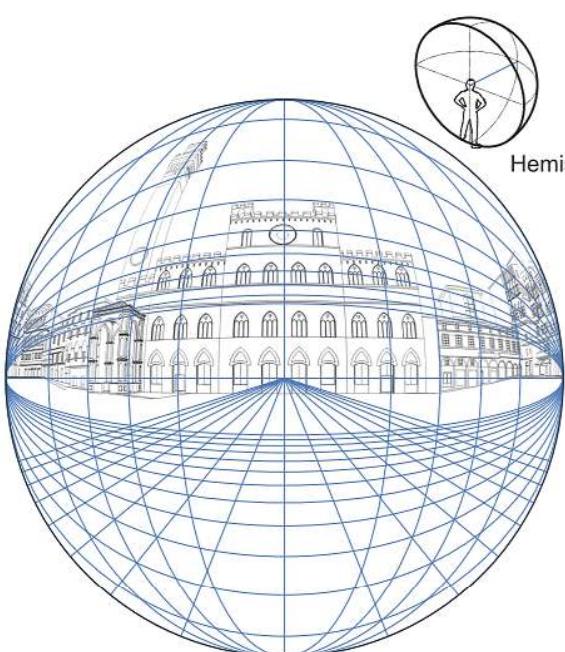
Linear



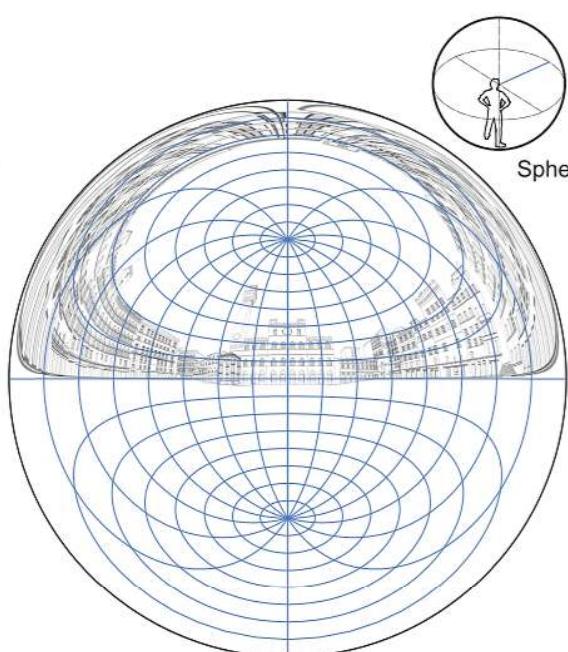
Four-point Perspective



Cylindrical



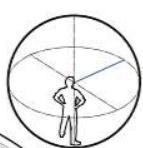
Five-point Perspective



Six-point Perspective



Hemispherical



Spherical

CONTENTS

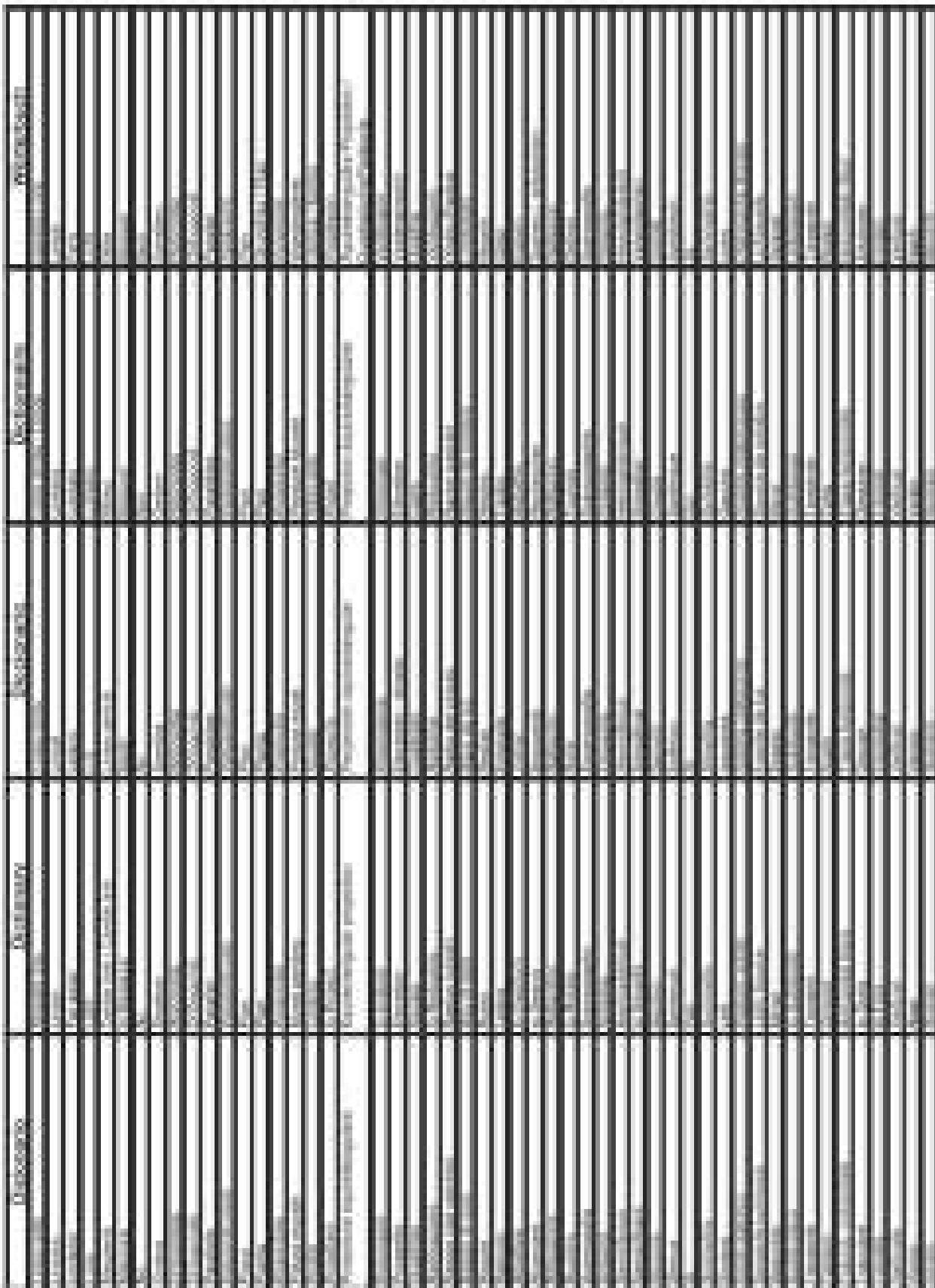
Chapter 1	Four, five and six-point perspectives	page 9
Chapter 2	Drawing perspective by equations	page 68
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- Anamorphosis
- Linear perspective (one, two, three-point perspective)
- Reflections
- Shadows

See the book (text in Italian):

"Prospettiva_ZeroSei", complete manual of perspective from 0 to 6 vanishing points"
<http://www.biodomotica.com/book.htm>

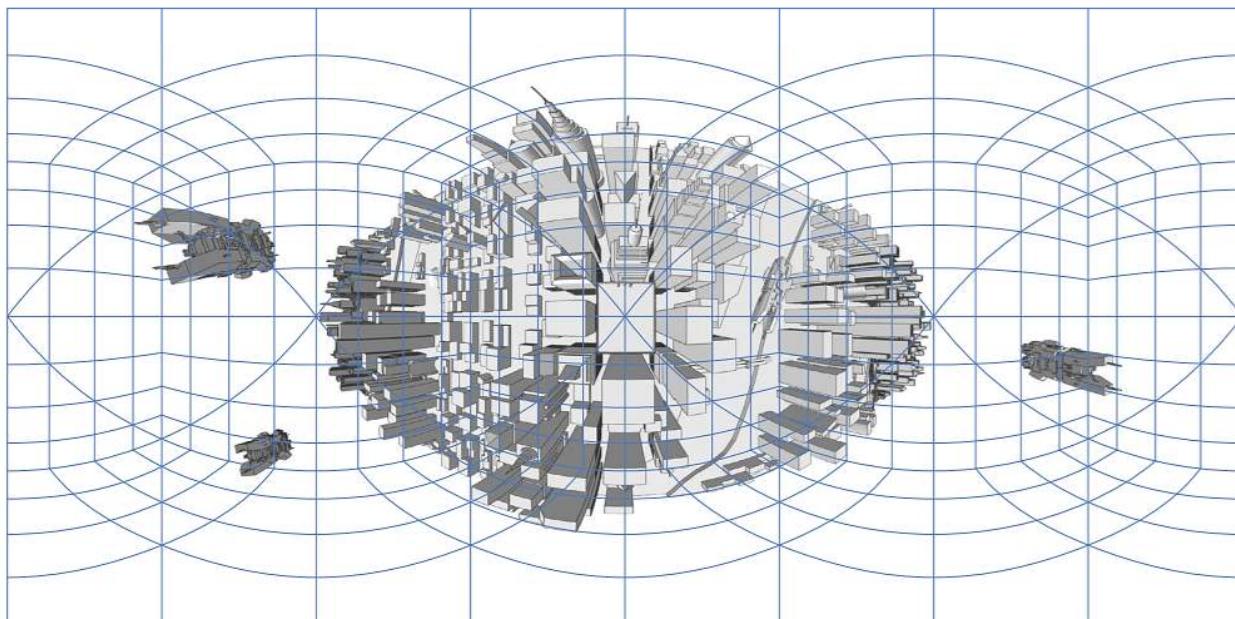
Dizionario	Dictionary	Diccionario	Dictionnaire	Wörterbuch
All'indietro	Backwards	Atrás	En arrière	Zurück
Allineare	to Align	Alinear	Aligner	Ausrichten
A mano libera	Freehand	A mano libre / a mano alzada	A main libre	Freihand gezeichnet
Amamorfosi	Amorphosis	Amamorfosis	Amorphose	Amamorphose
Angolo di incidenza	Angle of incidence	Ángulo de incidencia	Angle d'incidence	Einfallswinkel
Angolo riflessione	Angle of reflection	Ángulo de reflexión	Angle de réflexion	Reflexionswinkel
Aperto	Open	Abierto	Ouvert	Offen
Asse maggiore	Major axis	Eje mayor	Grand axe	Haupflache
Asse minore	Minor axis	Eje menor	Petit axe	Nebenfläche
Axonometria	Axonometric	Axonometría	Axonométrie	Axonometrie
Centro	Center	Centro	Centre	Zentrum
Cerchio	Circle	Círculo	Cercle	Kreis
Chiuso	Closed	Cerrado	Fermé	Geschlossen
Cilindrica	Cylindrical	Cilíndrico	Cylindrique	Zylindrisch
Circonferenza	Circumference	Circunferencia	Circonference	Umfang
Conica	Conical	Conico	Conique	Konisch
Confrontare	to Compare	Confrontar	Comparer	Vergleichen
Convergere	to Converge	Convergen	Convergent	Konvergieren
Correggere	to Correct	Corregir	Corriger	Korrigieren
Costituire	to Build	Construir	Construire	Konstruieren
Cubo	Cube	Cubo	Cube	Kubus / Würfel
Definire	Define	Definir	Définir	Definieren
Determinare	to Determine	Determinar	Déterminer	Bestimmen
Destra	Right	Derecho	Droit	Rechts
Diagramma	Diagram	Diagramma	Diagramme	Diagramm
Diametro	Diameter	Diametro	Diamètre	Durchmesser
Direzione	Direction	Dirección	Direction	Richtung
Disegno tecnico	Technical drawing	Dibujo técnico	Dessin technique	Technische Zeichnung
Distanza	Distance	Distancia	Distance	Entfernung
Distanza finita	Finite distance	Distancia finita	Distance finie	Erdliche Entfernung
Distanza infinita	Infinite distance	Distancia infinita	Distance infinie	Unendliche Entfernung
Distendere	to Stretch	Estiramiento	Allongement	Ausdehnen / Ausbreiten
Dividere	to Divide	Dividir	Diviser	Teilen
Ellisse	Ellipse	Elipse	Ellipse	Ellipse
Equirettangolare	Equirectangular	Equirectangular	Équerectangulaire	Äquirektangulär
Equivalent	Equivalent	Equivalente	Équivalent	Äquivalent
Esempio	Example	Ejemplo	Exemple	Beispiel
Fianco	Side	Lado	Côte	Seite
Fissare	Fix	Fijar	Fixer	Befestigen
Frontale	Frontal	Frontal	Frontal	Frontal
Goniometro	Protractor	Goniómetro	Rapporteur	Winkelmesser
Grandangolo	Wide-angle lens / Fisheye	Lente gran angular	Objectif grand-angle	Weitwinkel-Objektiv
Griglia	Grid	Cuadrícula	Grille	Gitter
In avanti	Forward	Adelante	En avant	Nach vorn
Inclinazione	Inclination	Inclinación	Inclinaison	Neigung
Individuare	to Locate	Localizar	Localiser	(die Position) ermitteln
Ingrandire	to Enlarge	Agrandar	Agrandir	Vergrößern
Intersezione	Intersection	Intersección	Intersection	Schnittpunkt
Isonettrico	Isonettrico	Isonettrico	Isonétrique	Isonetrisch
Laterale	Lateral	Lateral	Lateral	Seitlich
Lato	Side	Lado	Côte	Seite



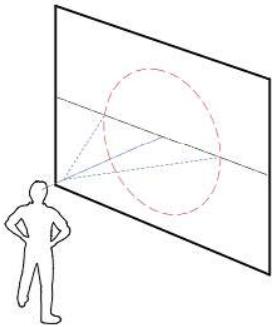
A dense grid of black vertical bars on a white background. The bars are evenly spaced and extend from the top to the bottom of the frame. There are no other elements or text present.

Chapter I

4 - 5 - 6 vanishing points

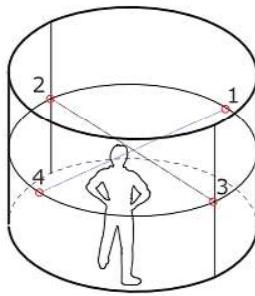


Equirectangular Projection (360°)



The classical perspective, with straight lines. The maximum angle for the cone of vision is 60 degree.

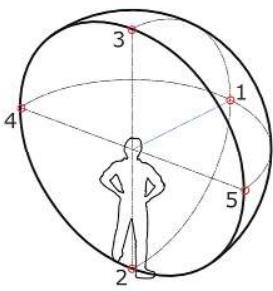
Linear



In this perspective the horizontal lines are curved and the vertical are still straight lines.

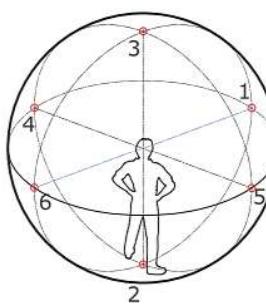
In the case of a complete cylindrical view, the horizontal width ranges from 180° to 360°.

Cylindrical



In the spherical perspective, horizontal and vertical lines are curves. The panorama is limited to vertical and horizontal angles of view of 180 degrees.

Hemispherical



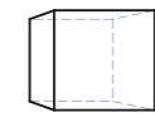
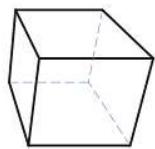
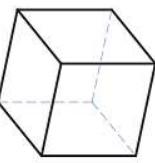
With the projection onto the sphere, is possible to draw a 360-degree panorama, also including the ceiling and the floor.

Spherical

Linear perspective

0 vanishing points	1
	The classical perspective, with straight lines
	Axonometric is considered a perspective without vanishing points
	

2

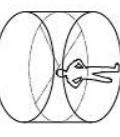


Central perspective
Two-point perspective
Three-point perspective

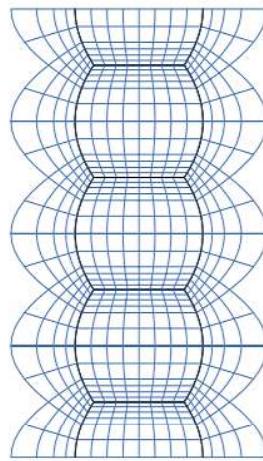
Curvilinear perspective

4 vanishing points	5
	
Cylindrical field of vision	Hemispherical field of vision

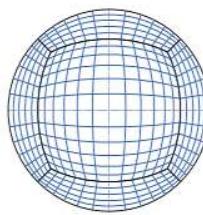
6



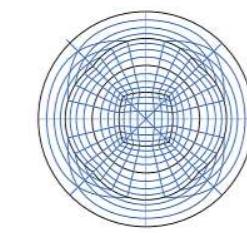
Spherical field of vision



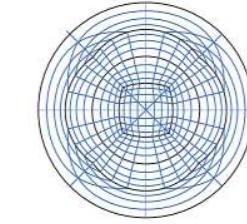
A 360-degree horizontal view and
a 180-degree vertical view



A 180-degree horizontal view and
a 360-degree vertical view



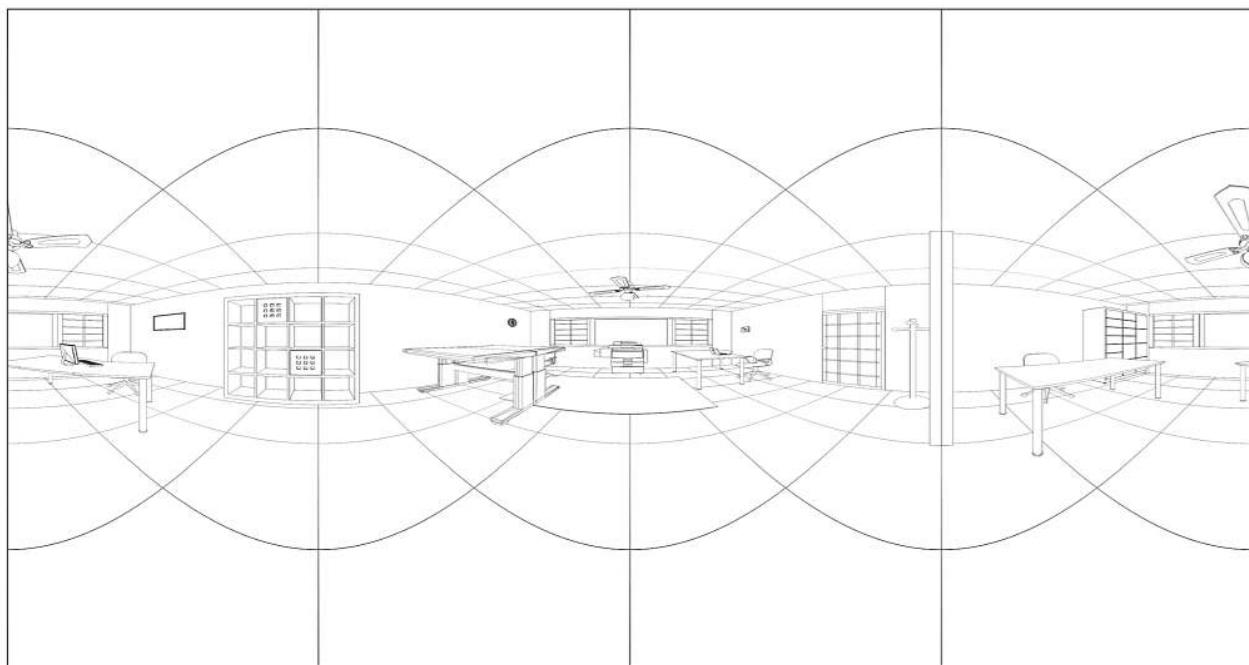
A 360-degree horizontal view and
a 360-degree vertical view



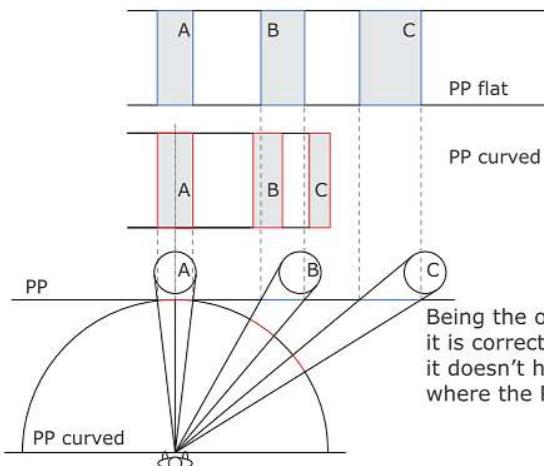
Summary types of perspective based on Vanishing Points

4 vanishing points

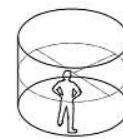
Cylindrical perspective



4-point perspective



Cylindrical perspective



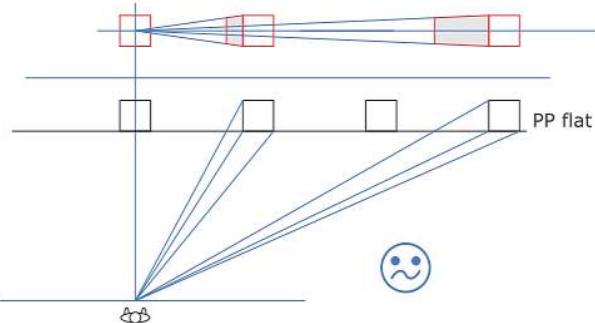
In this perspective, the horizontal lines are curved.

Being the object C farthest of A from the observer, it is correct that this is seen smaller; it doesn't happen with the classic perspective where the PP is flat.

The observer is inside a transparent cylinder. The surface of the cylinder intercepts the light rays that reach the Observer from the objects, determining a draw that, when unrolled and flattened, produces a draw with curved lines (curvilinear perspective). Curvilinear perspective has a 360-degree field of view, with the disadvantage of curved lines, as is the case with very short focal length or wide-angle focal lenses (called fisheye). Looking inside a cylinder, the curved lines of the curvilinear perspective would appear straight to us because turning the head is like being presented with infinite linear picture planes.

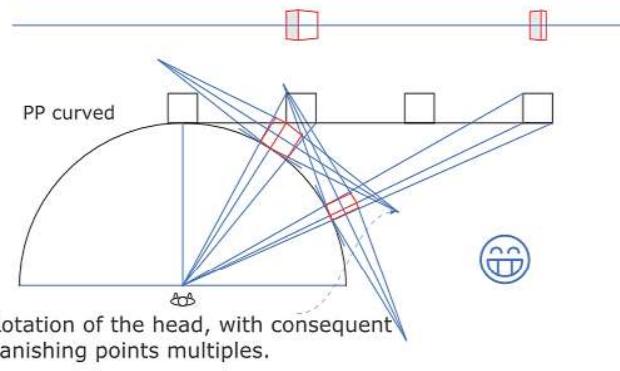
Objects in linear perspective, placed at the ends of the visual field, are seen stretched, an effect that does not occur in reality.

Linear view



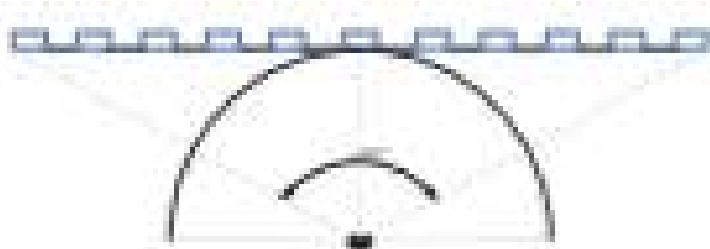
Cylindrical view

The human field of vision is considered curved; this is partly because the eye is spherical and partly because we rotate the head to look around.



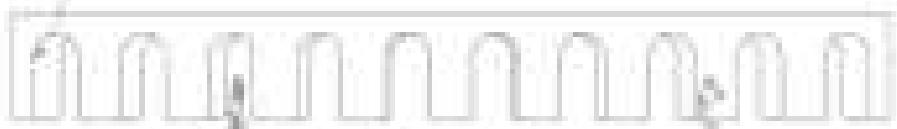
Rotation of the head, with consequent vanishing points multiples.

Cylindrical perspective



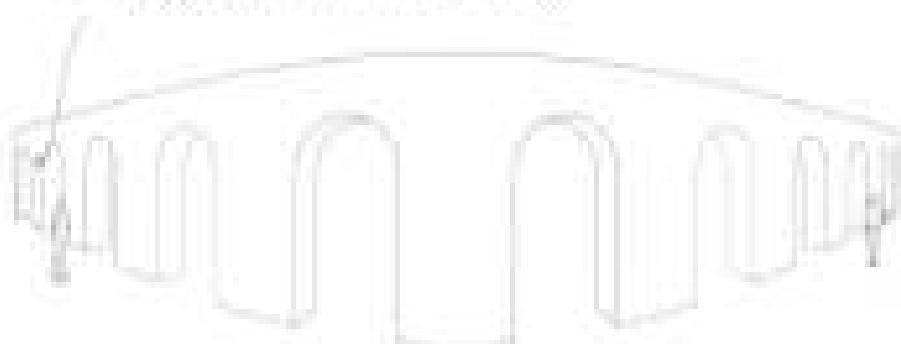
This form of vision is called *cylindrical*. The people in our society often use this type of vision, particularly without realisation.

Associated with the boundaries of the visual field. The distance between elements and between the centres of the eyes are maintained.



Frontal shear projection

This is more "natural human view".
Using rectangles, the size of objects is reduced.

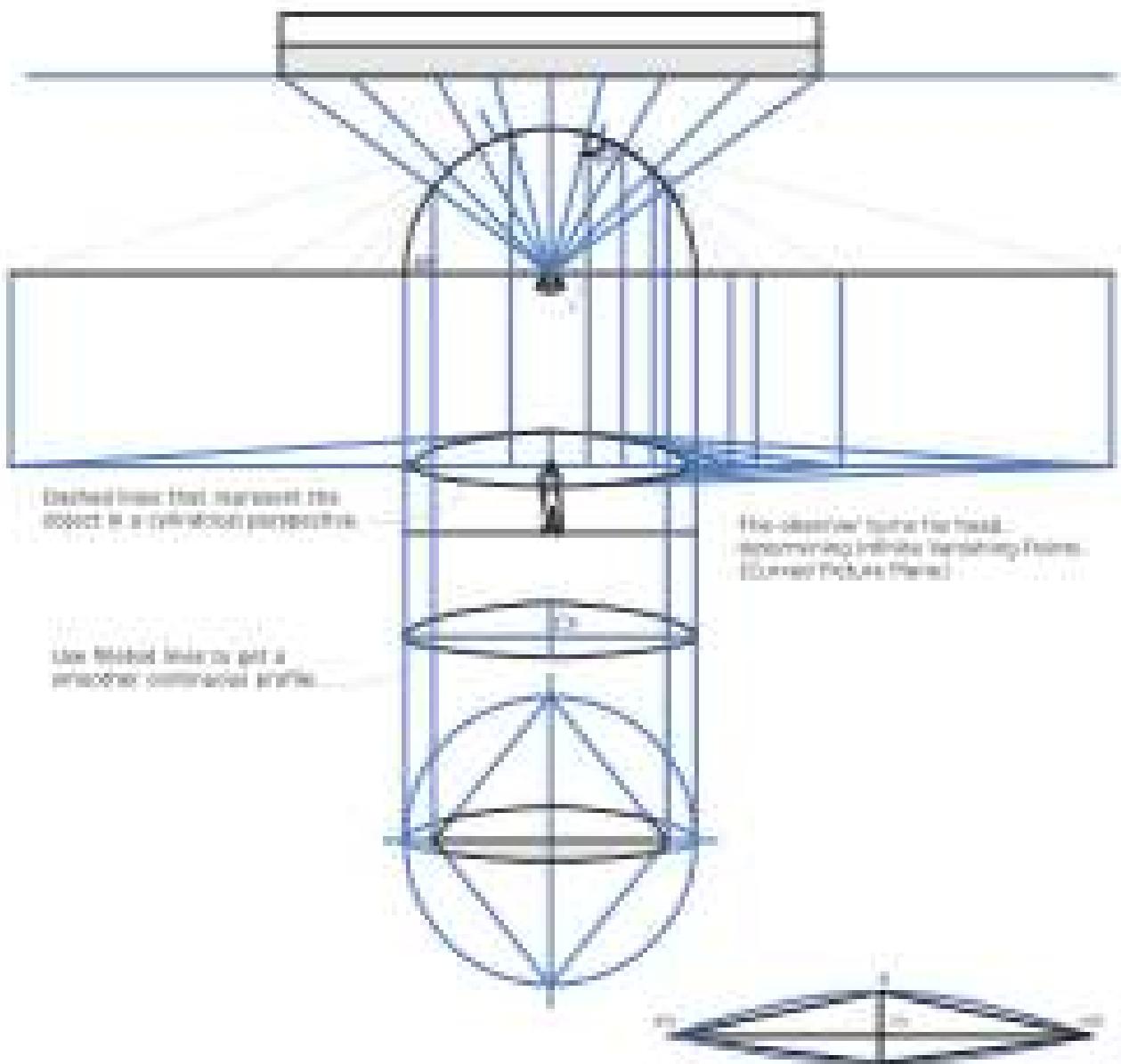


Frontal cylindrical projection



Differential competition

function of the genome in disease and disease prevention



On the basis of our treatment this
object is a very robust perspective.

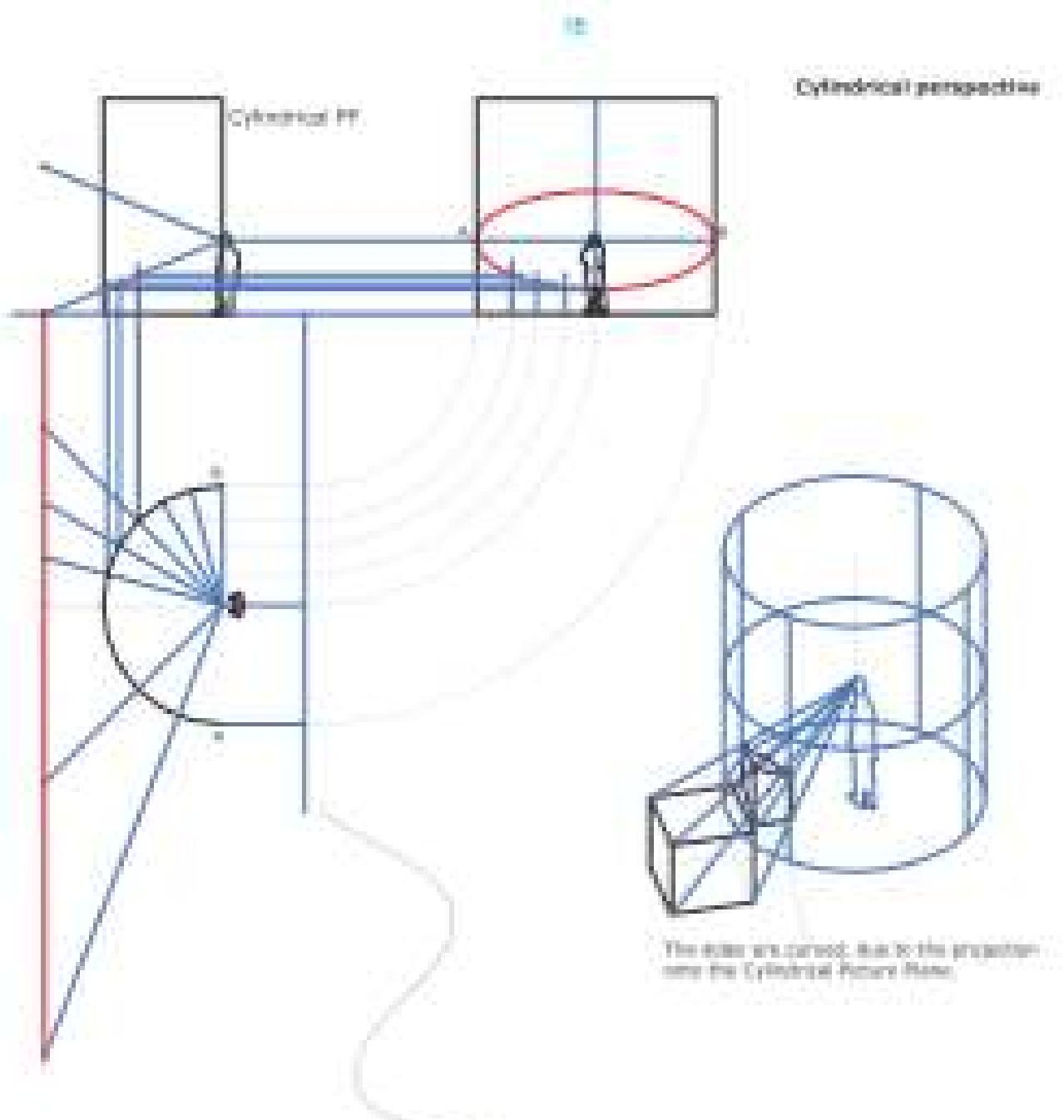
The-shoulder-tucks-the-head—
discreetly initiating Veneration Themes
[Convey Positive Themes]

The United States gets a
stronger congressional profile

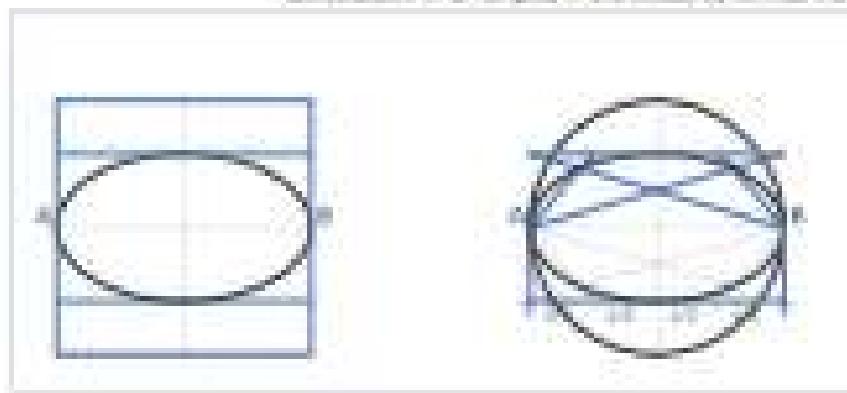
[View all posts by admin](#) | [View all posts in category](#)

"The question I have always been asked is, 'What is your best advice for the first fifteen minutes, and using the changing types of library perspectives, it's about trying to assess what you're going to do."

These first results of the experiment (T) show not much. The change (P) is the hypothesis that only people who receive positive feedback tell a second lie.

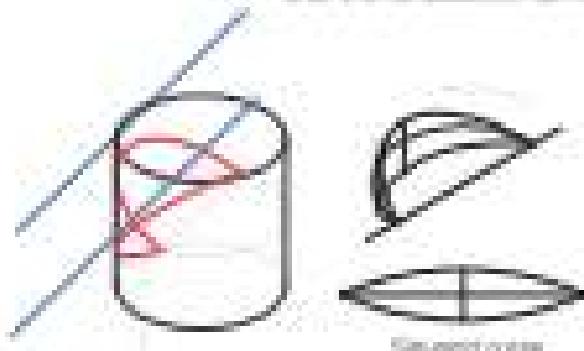


Conclusion of our study on the family structure

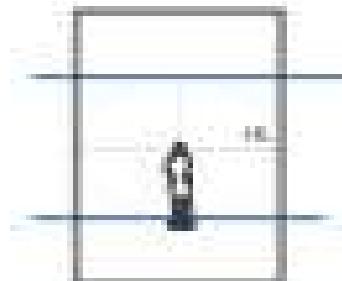


Cylindrical perspective

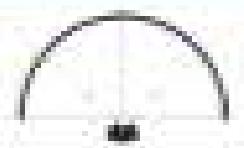
The parallel lines projected on the cylinder (P_1) after the first oblique (unrolling), form a turn curve.



Projection of parallel lines onto the cylindrical visual field.

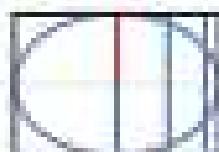


Line to be projected onto the cylinder



Carried cylinder

H represents the width of angle.
Divided into n equal parts.



Front

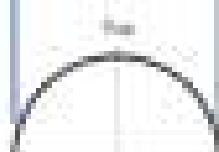
the parallel lines projected on the cylinder (P_1)
after the first oblique (unrolling), form a turn curve.

Cylinder carried on a plane

unrolled



Division into n equal parts.

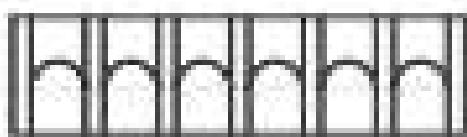


Dimensioning of the unrolled P1

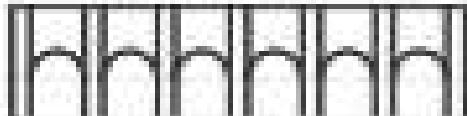
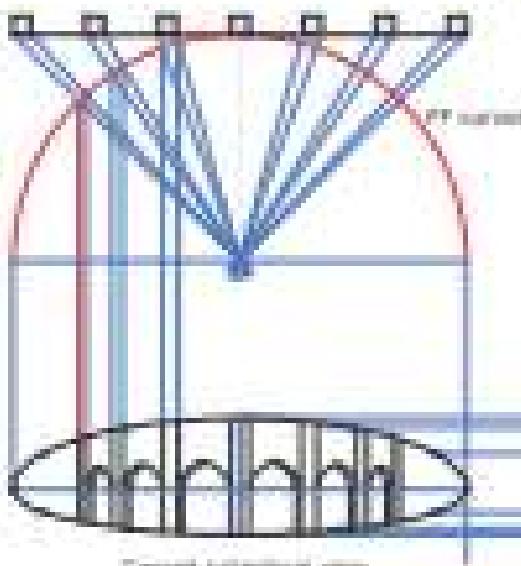


Dimension unrolled unprojection

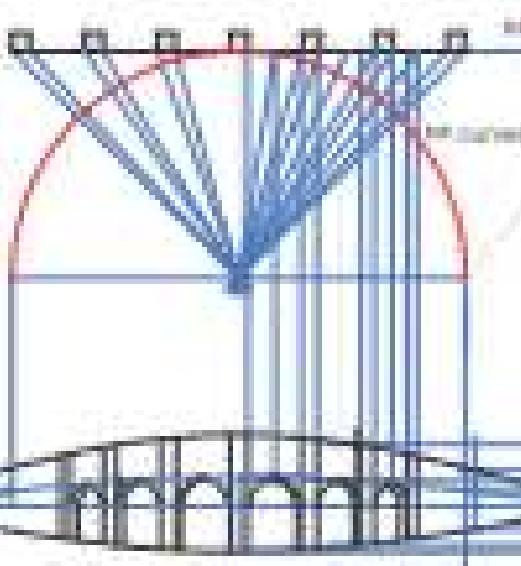
Cylindrical perspective



Height used for the construction
of the corner shapes.



Height used for the construction
of the corner shapes.



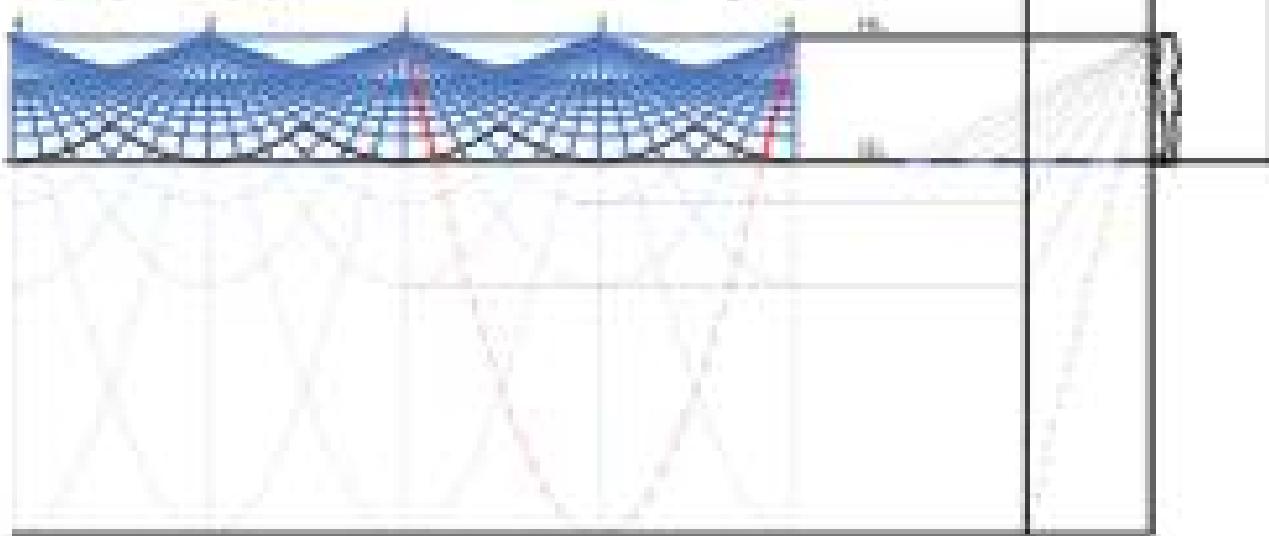
Cylindrical view oriented onto the plane

Cylindrical perspective



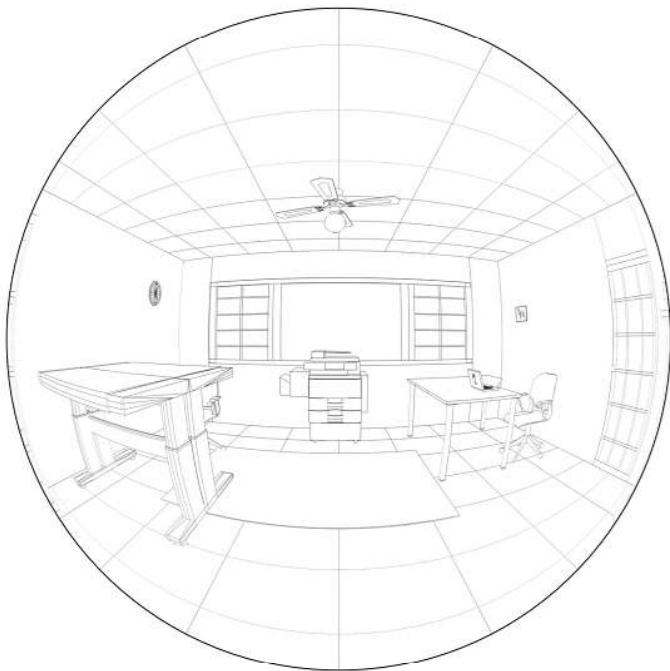
To avoid excessive distortion, it is better to use only the perspective view (which has maximum field of view) or use the spherical projection on the reference plane (explained later in the chapter – equirectangular projection).

Simple cylindrical projection



5 vanishing points

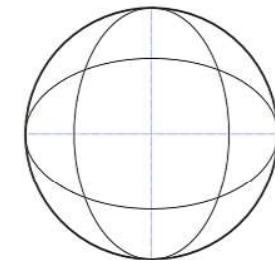
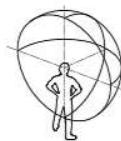
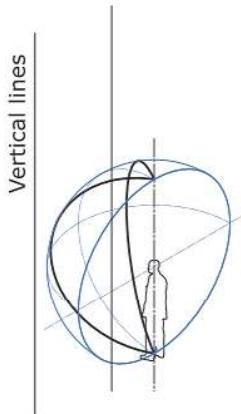
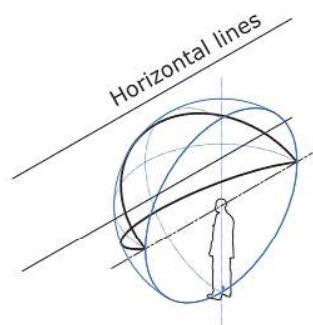
Hemispherical perspective



5-point perspective

Hemispherical field of vision

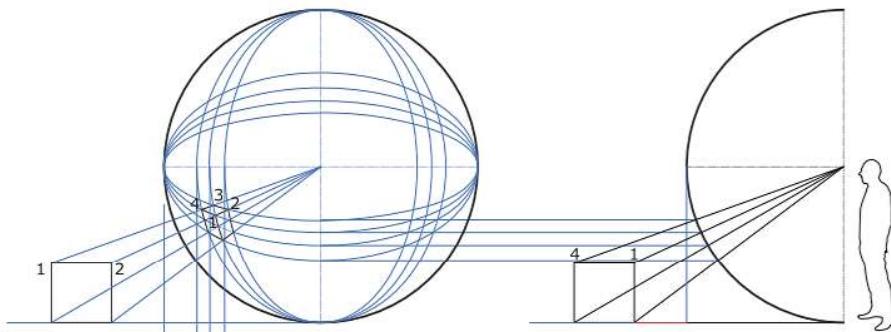
Projection of parallel lines onto the hemispherical surface.



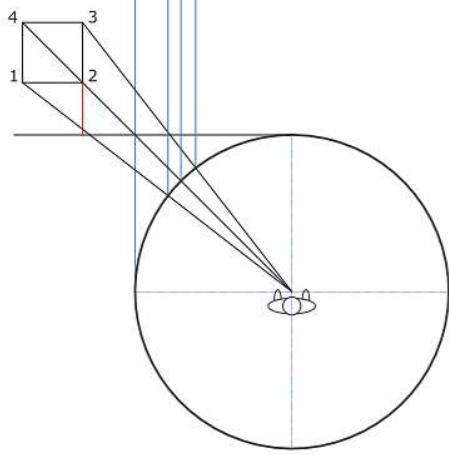
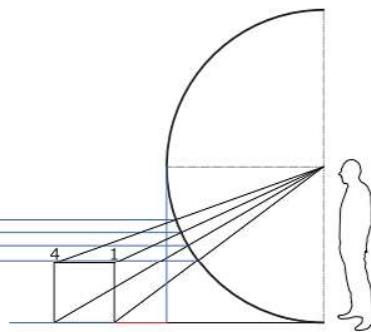
Front view of the curves projected onto the hemisphere.

Projection of a cube onto the hemispherical field of vision.

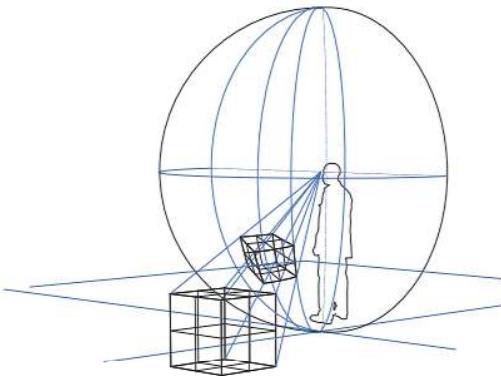
Front view



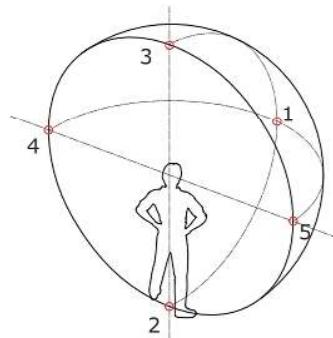
Side view



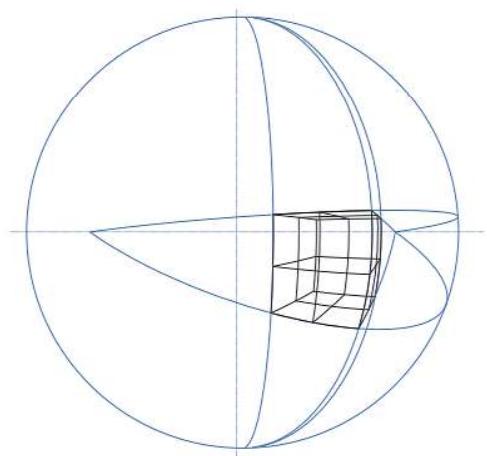
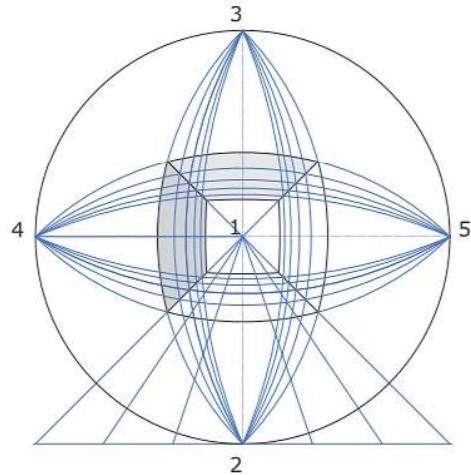
Plan view



Hemispherical field of vision

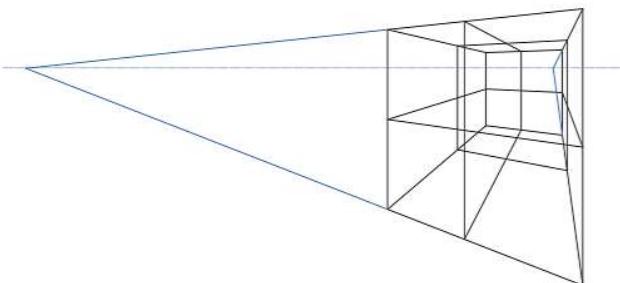


5 vanishing points



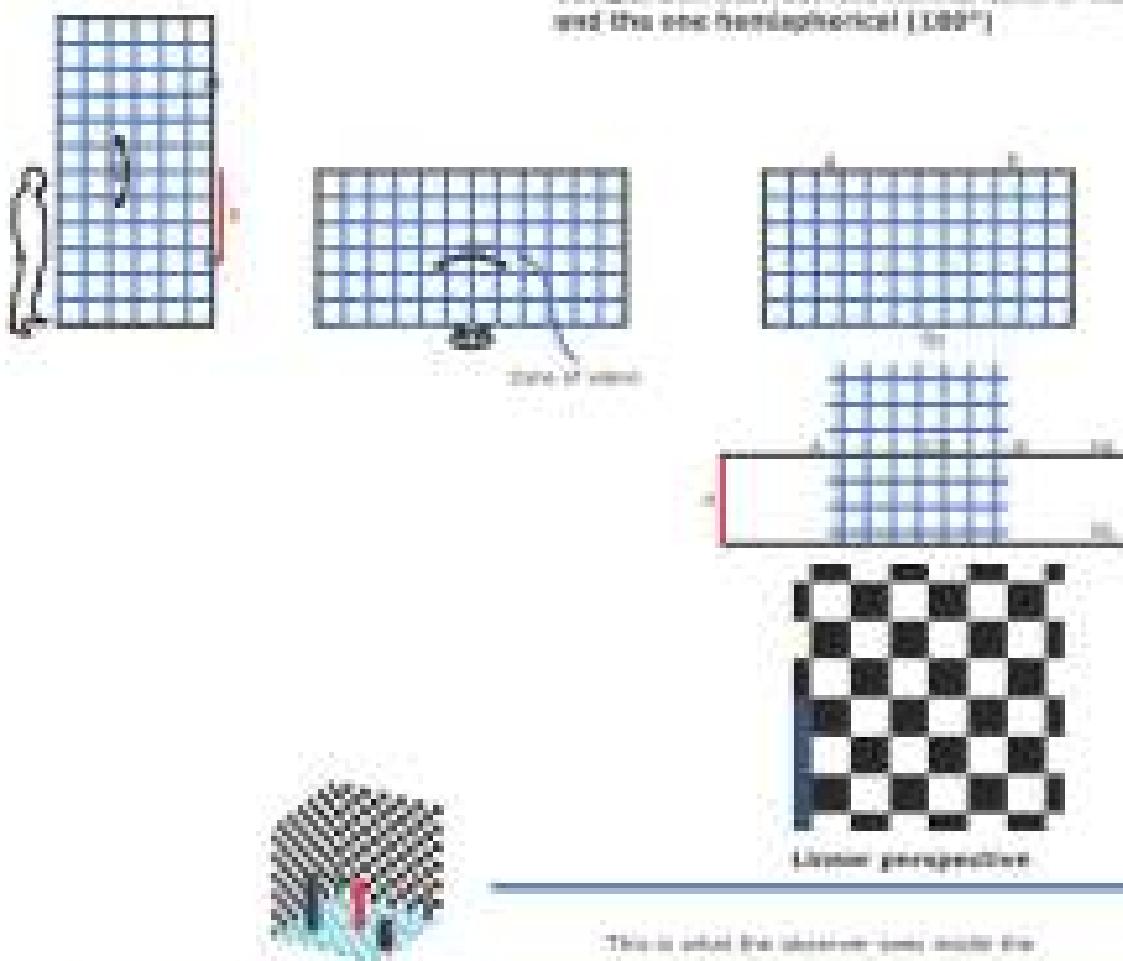
Curvilinear perspective

The same cube is seen from two different perspectives.

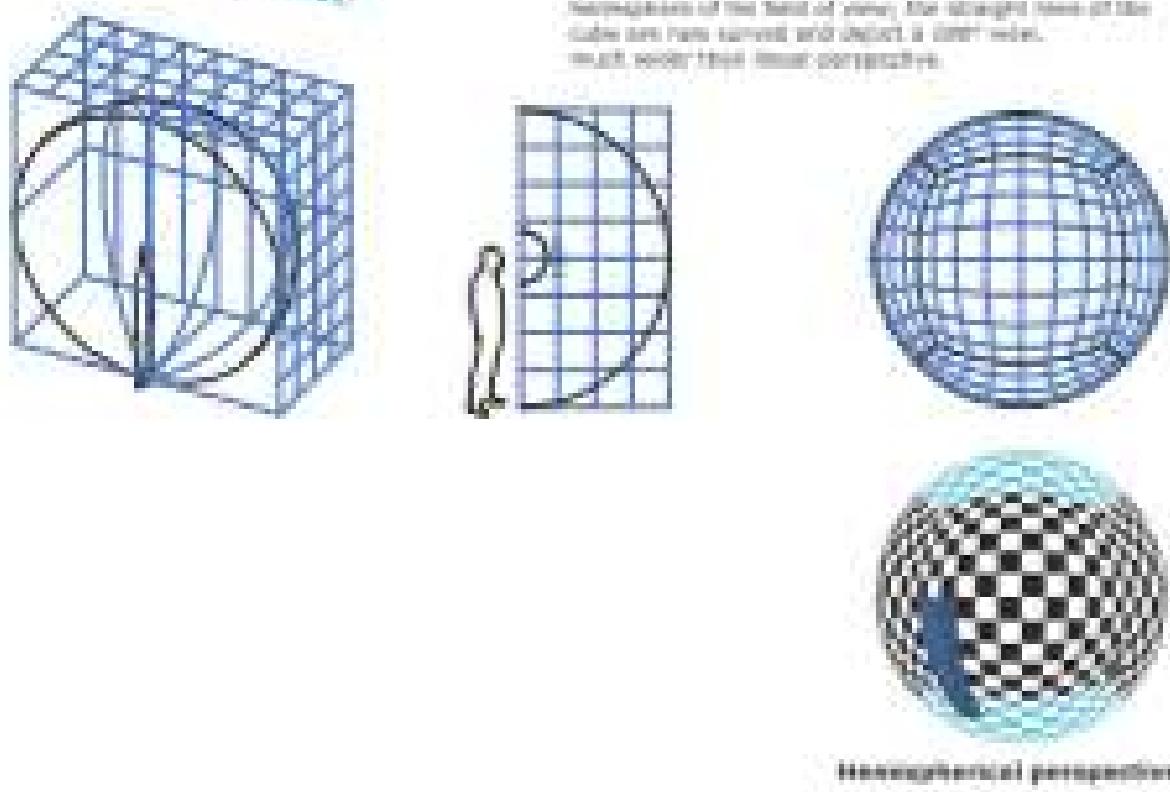


Linear perspective

Comparison between the normal view of slices (2D^{2D}) and the iso-hemispherical (3D^{2D})



This is what the volumes look like.
Reconstruction of the base of view. The original base of the cube has been curved and takes a semi-circle.
much better than 2D^{2D}!



Hemispherical perspective

Hemispherical field of vision flattened



3. Hemispherical Pattern



Pattern

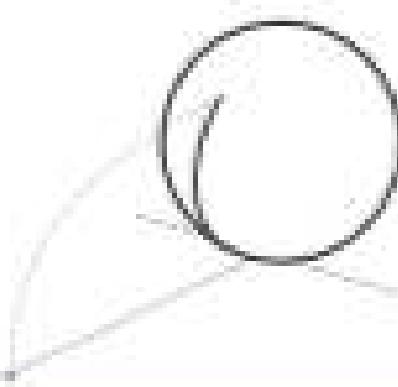


Flattening of the hemisphere

Flattening of the hemisphere onto the plane

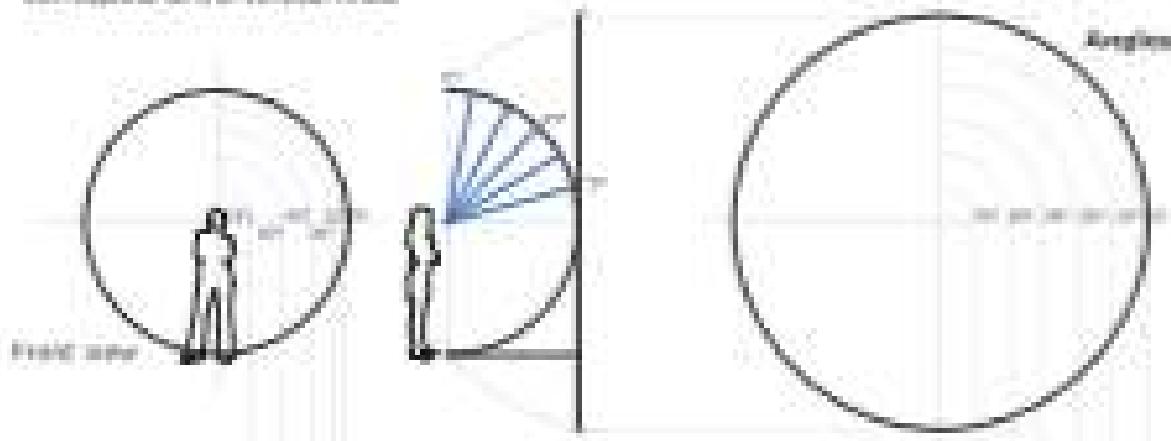


To calculate the length of an arc:
 $\theta = r \cdot 180^\circ / \pi$ $r = \text{arc length}$
 $\pi = \text{value of the circle}$
 $\alpha = \text{angle of the sector}$
 $\pi = 3.1415$



monocular field of vision

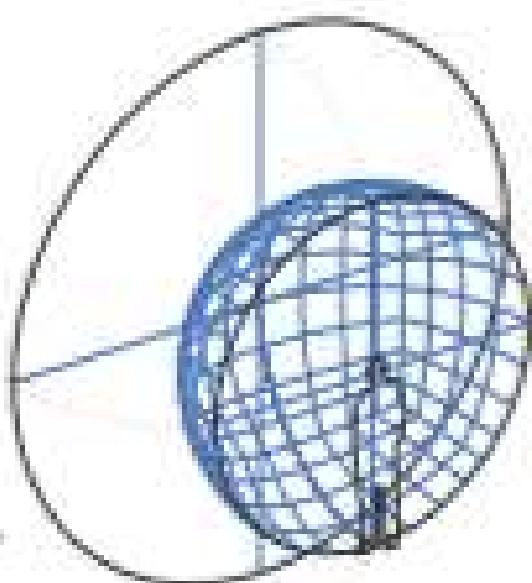
The object's horizontal angles
correspond to the visual axes.



With one eye closed, the other eye's angle points
the same areas toward the horizontal line.

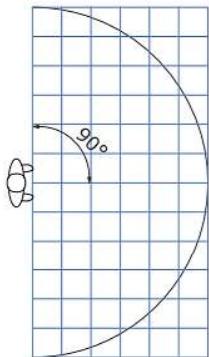


binocular overlap

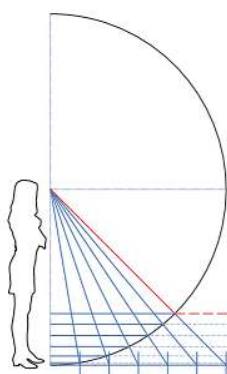


**Hemispherical field of vision CURVED
Grid 90°**

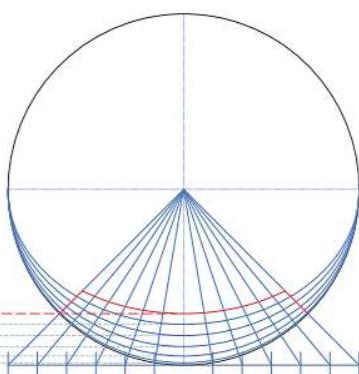
Perspective diagram



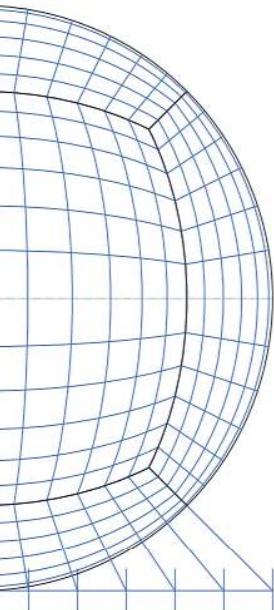
Plan view



Side view



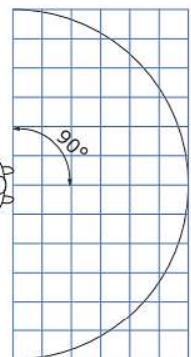
Front view



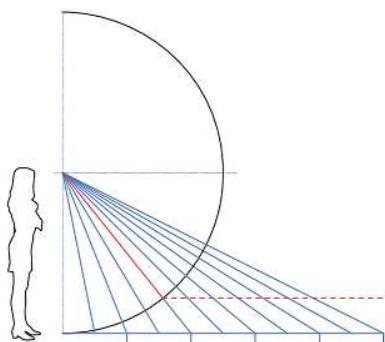
Complete perspective diagram

**Hemispherical field of vision CURVED
Grid 90°**

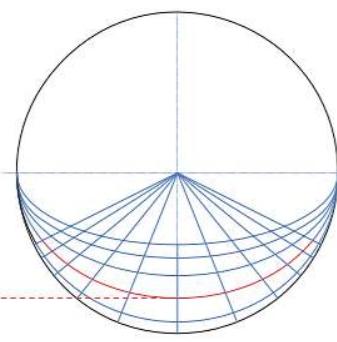
Perspective construction



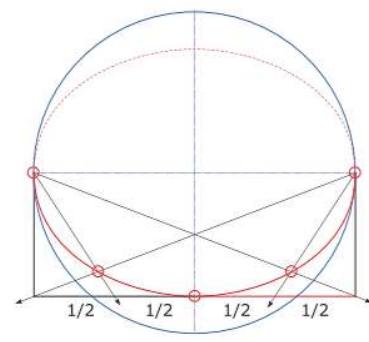
Plan view



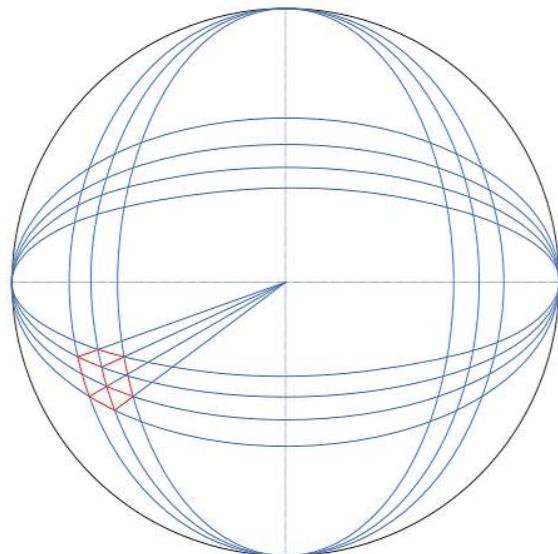
Side view



Construction of ellipses



Curve is defined by 5 control points



Example

Hemispherical field of vision (Covered area 48°)

Perspective diagram

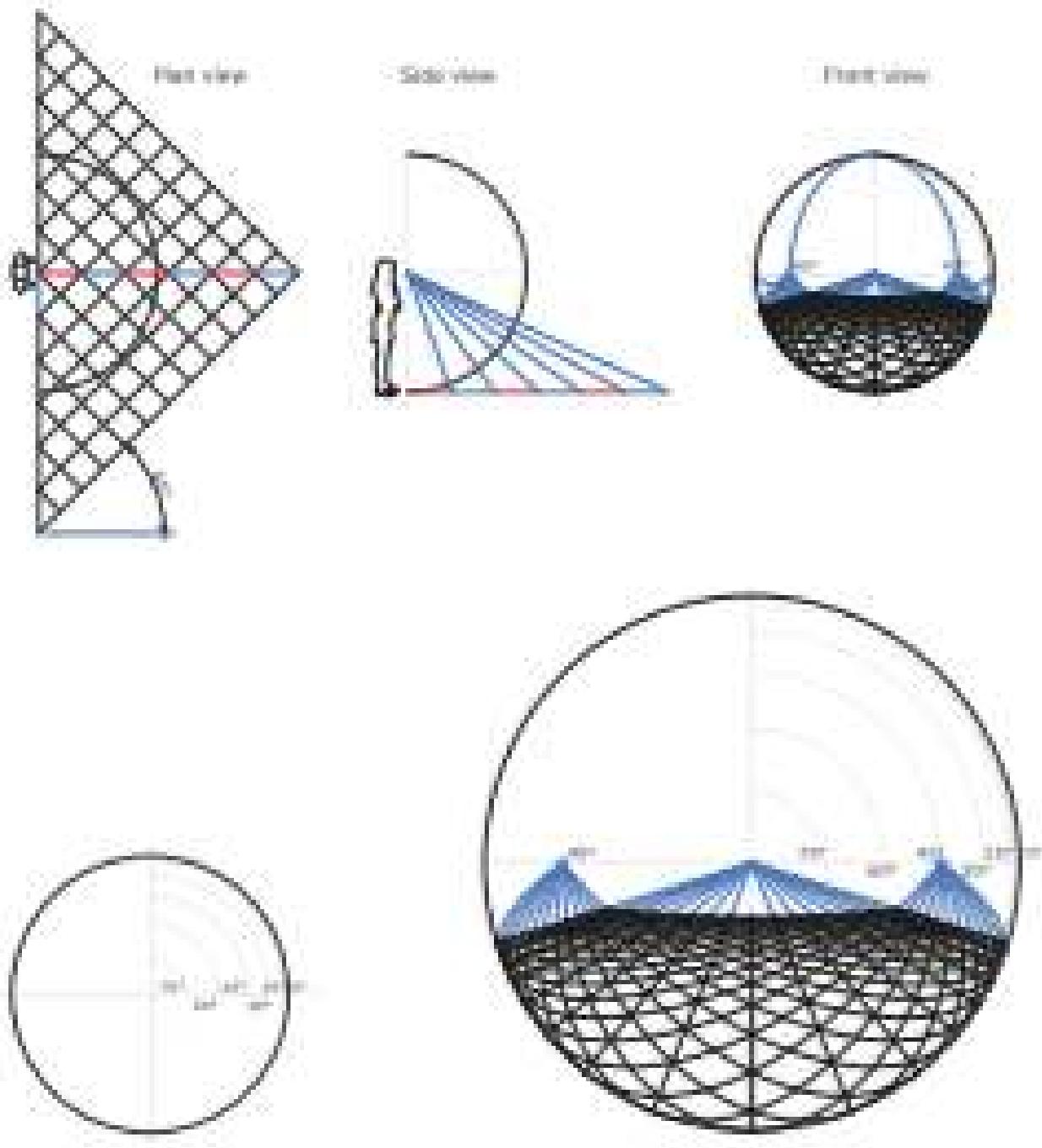
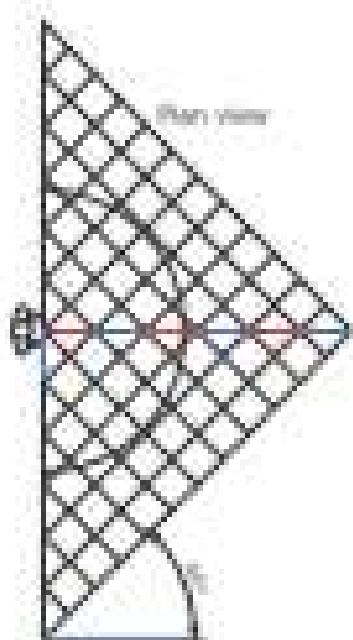


Diagram of arrangement of the eye(s), as observed from a posterior point of view.

Our first perspective diagram.



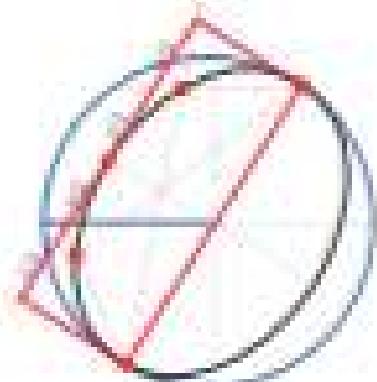
Grid view



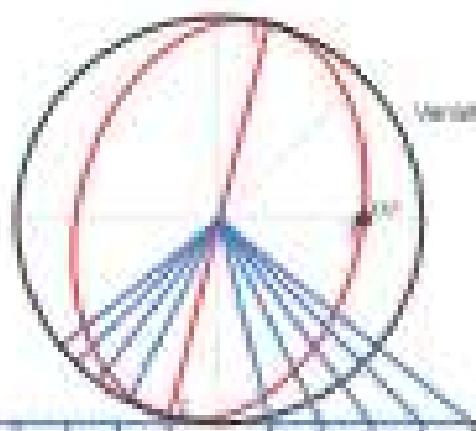
Gaze view

Hemispherical field of vision (Circumferential field 45°)

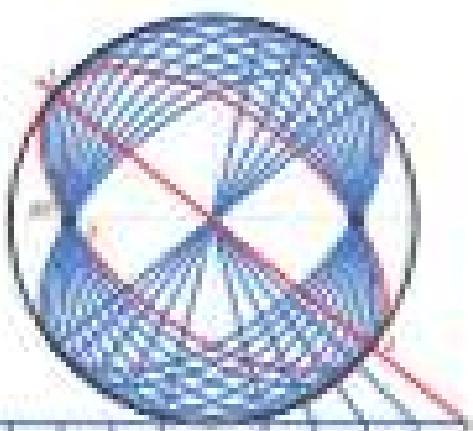
Perspective construction



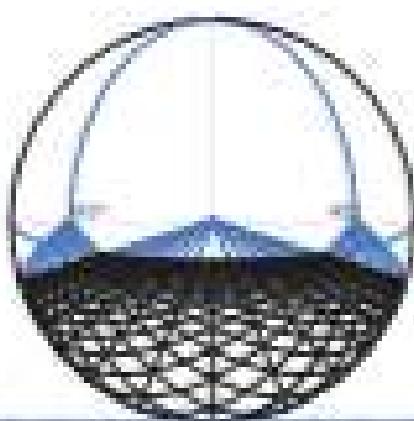
Construction of a horizon ellipse.
Center defined by 8 central points.



Vanishing pole - 45°



Construction ellipse by 3 green points through the 45° pole



Completed perspective diagram

Hemispherical field of vision (Diameter 180°)

Perspective diagram

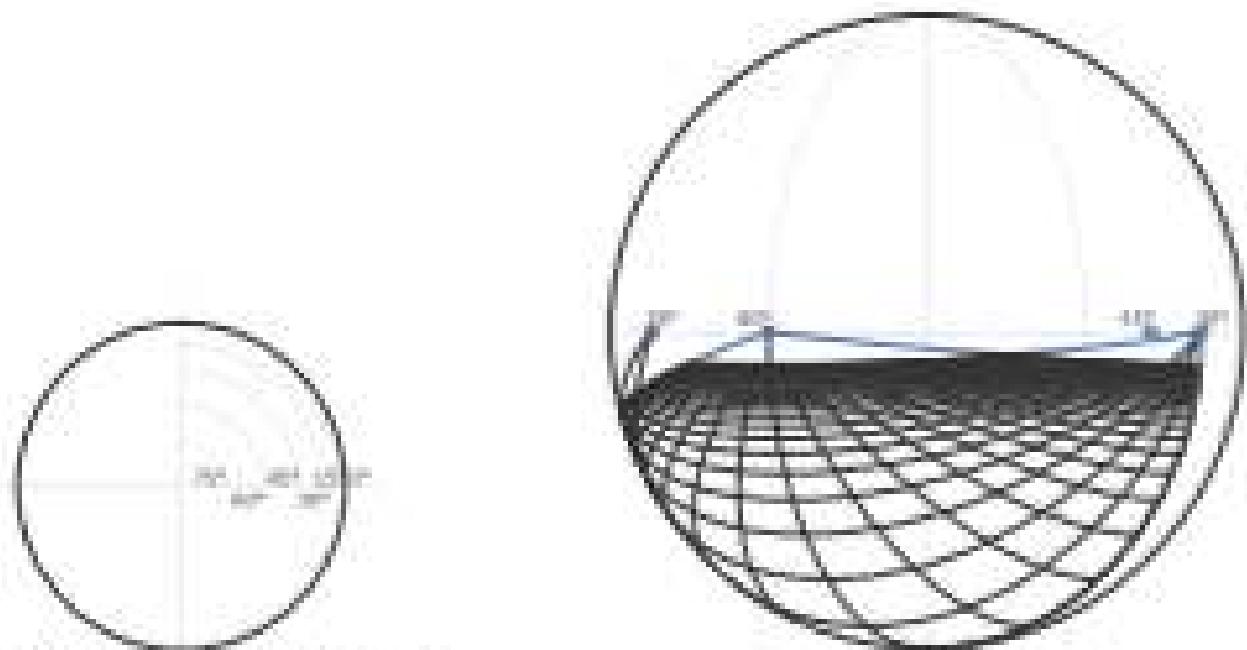
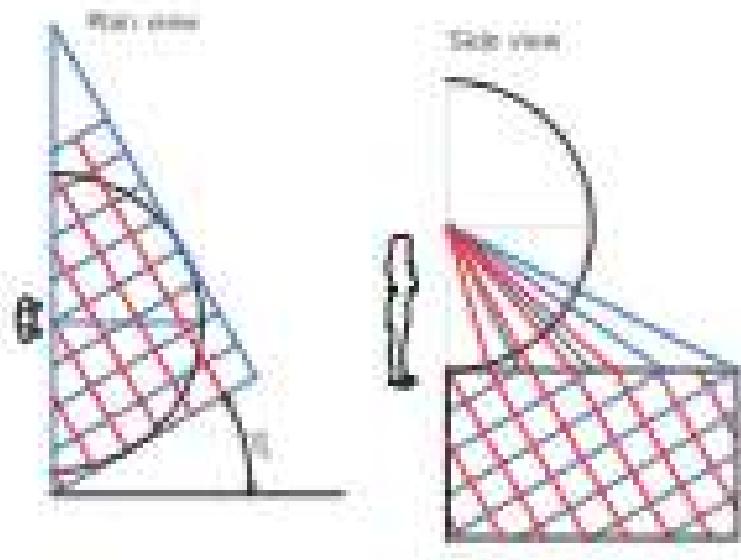
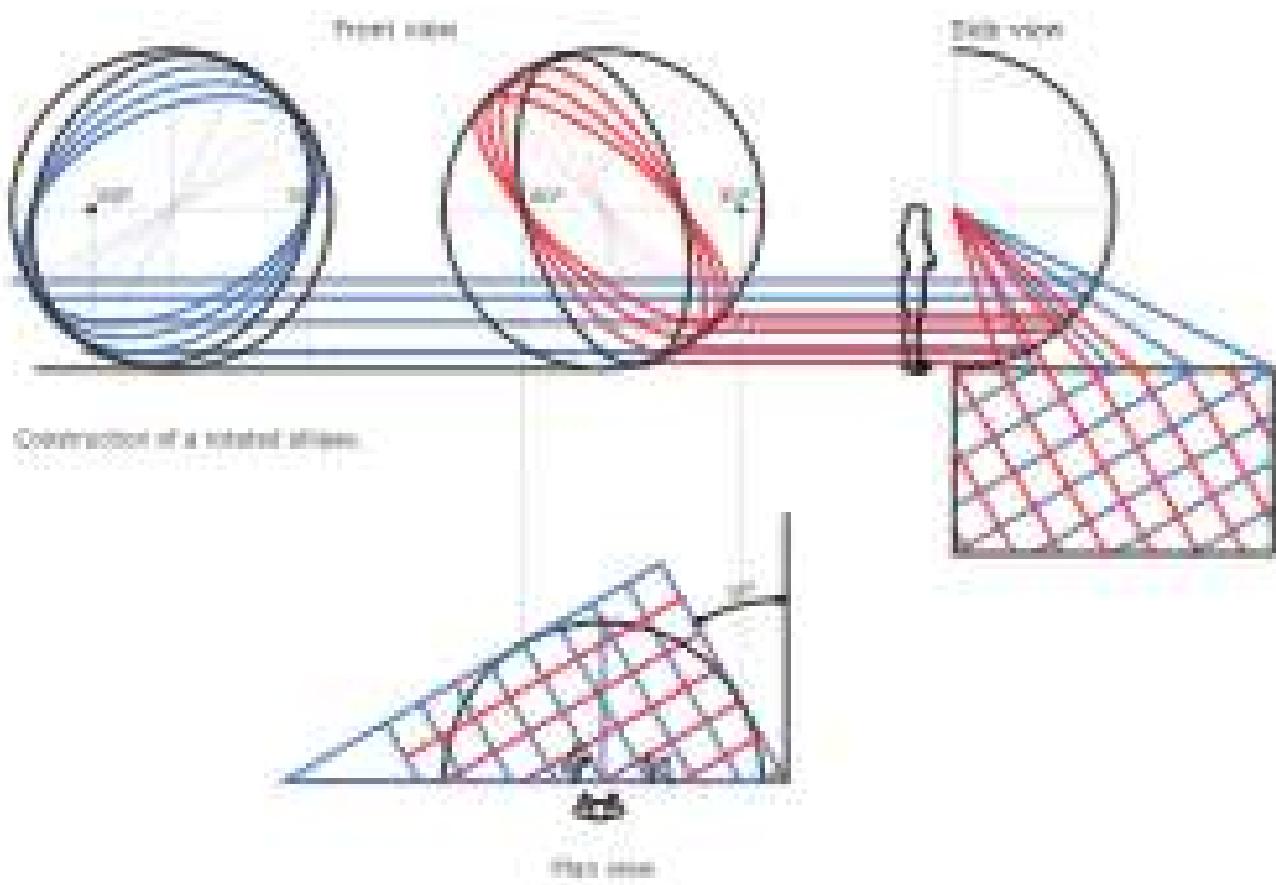
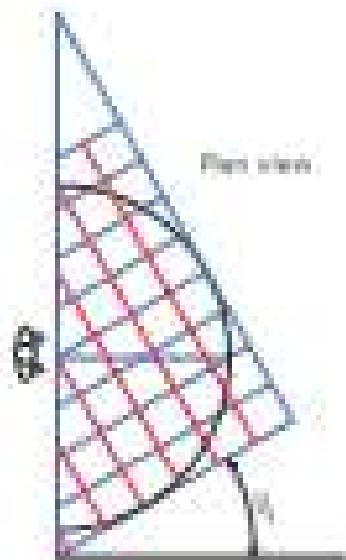
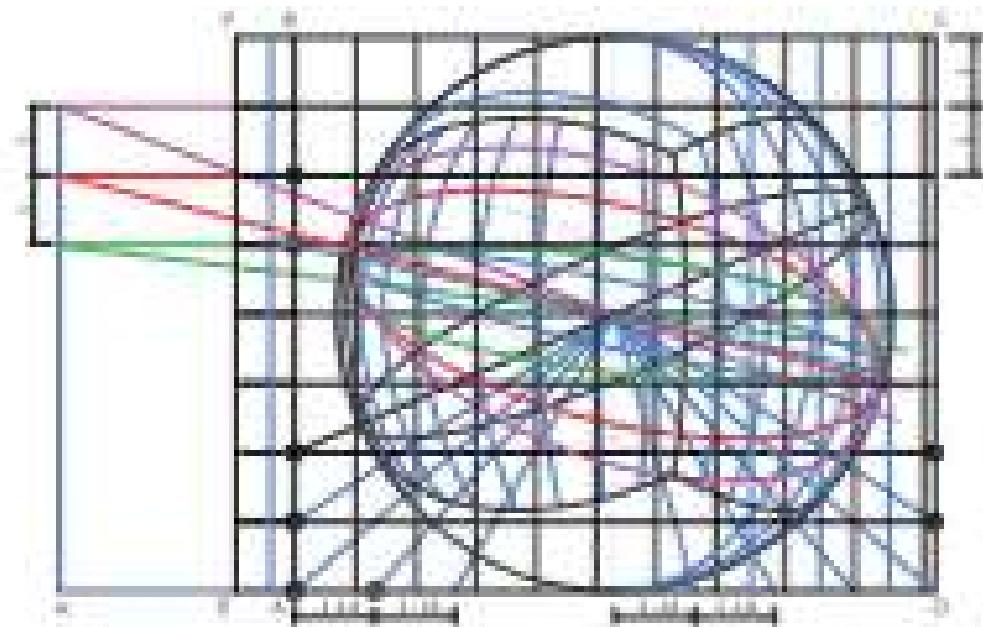
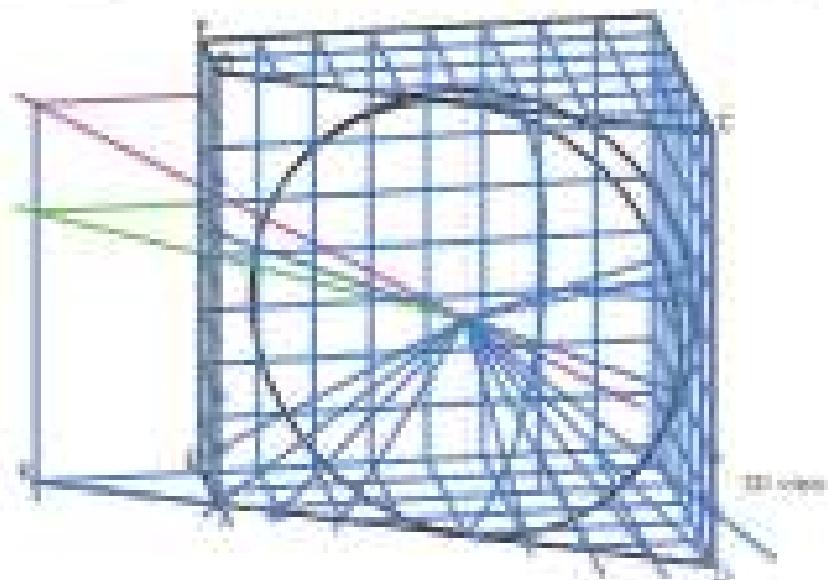
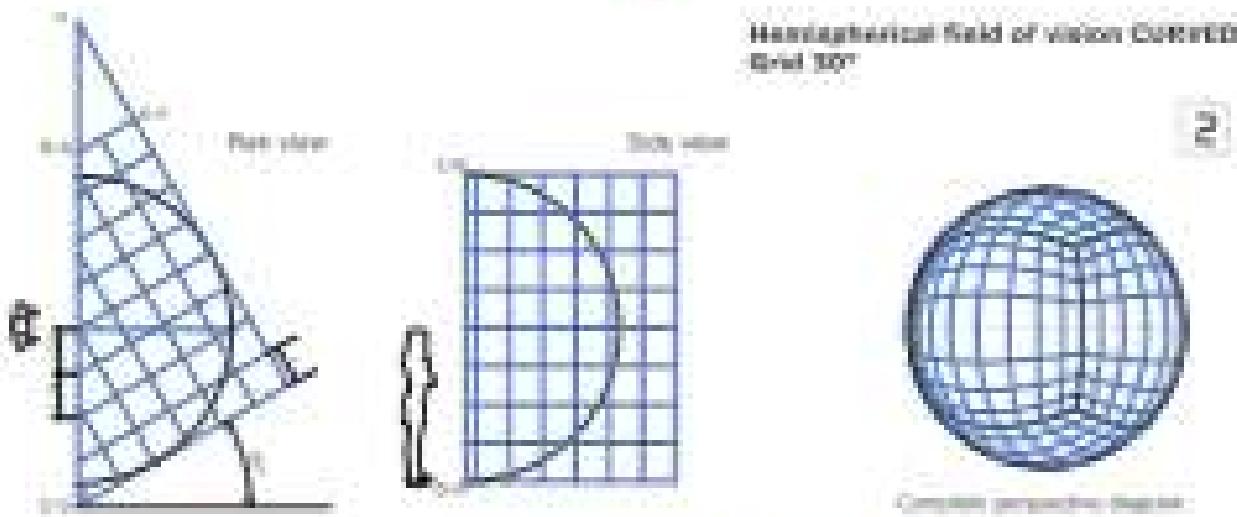


Diagram of arrangement of the eyebox in a curved hemispherical field of vision.

Curved perspective diagram.

Homonymous field of vision (Converging eyes)





Hemispherical field of view PLATINUM Grid '93'

Perspective Diagram

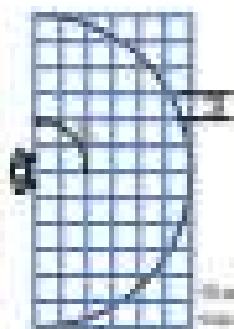


Chart of the projection of a hemispherical scene onto a grid plane.

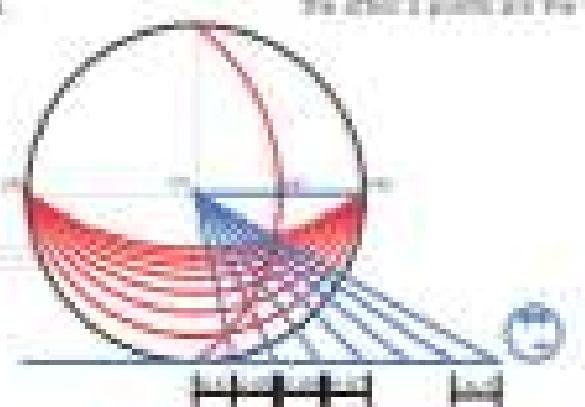
Plan view:

Transfer the measures of angles, on a vertical plane, the points of origin intersected by the meridians of the scene. This leads, following the last hemisphere, to the half of view.



Transfer the grid points to the D3.

With this new point, draw a cone passing through it points, where the other 8 points are the points.

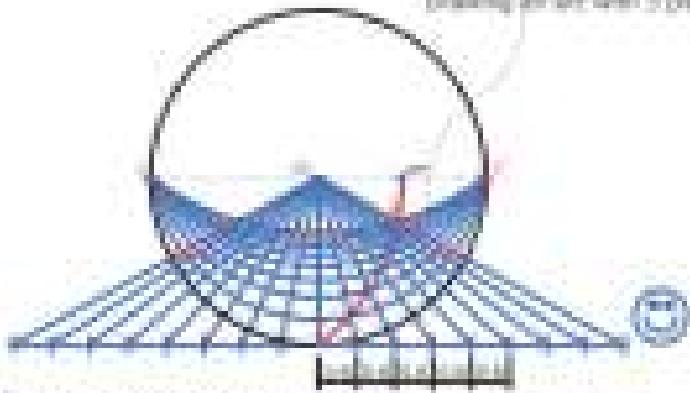


It is possible that the rays that converge towards the D3, thanks to the intersection of the horizontal axis and the 45° axis.

In this way, the drawing of the scene, after the plotting of the hemisphere field of view, are perspective and not linear.

To have a regular texture for drawing, it is necessary to make the divisions of the lines parallel to each other.

Drawing point with 8 points

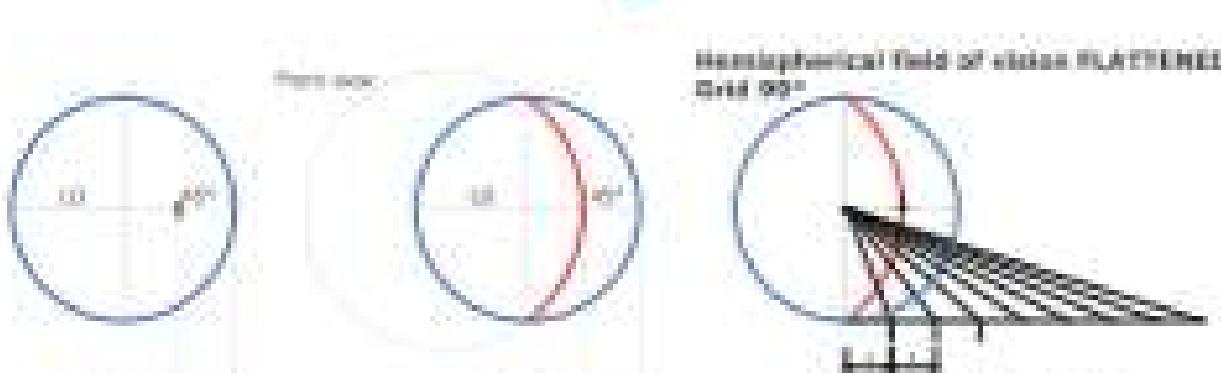


Draw line with equal divisions.

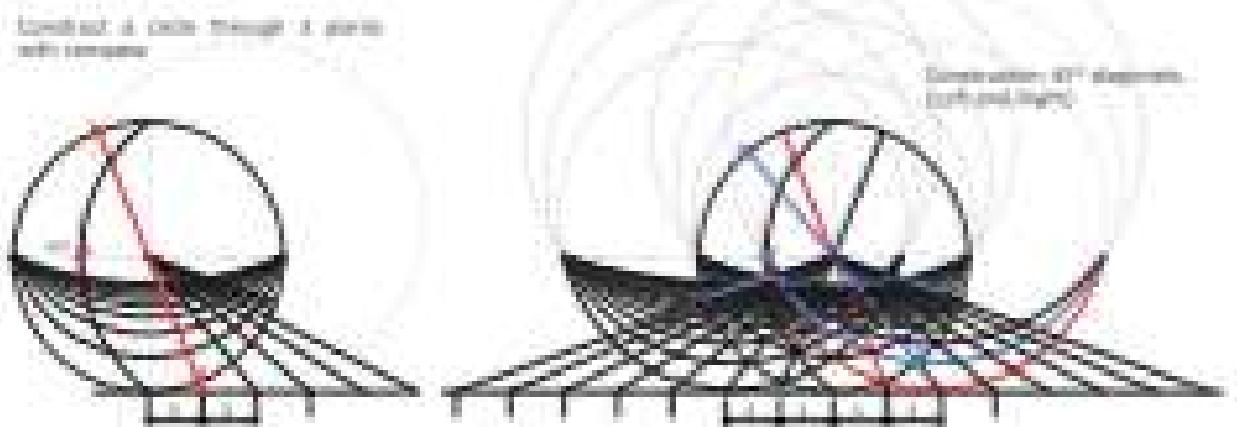
In this step, first drawing a base line with equal segments, and then from the intersection with the D3 axis, draw parallel axes at an angle of 45°, which represent the horizontal line of a grid projected onto the hemispherical field of view.



Complete perspective diagram.

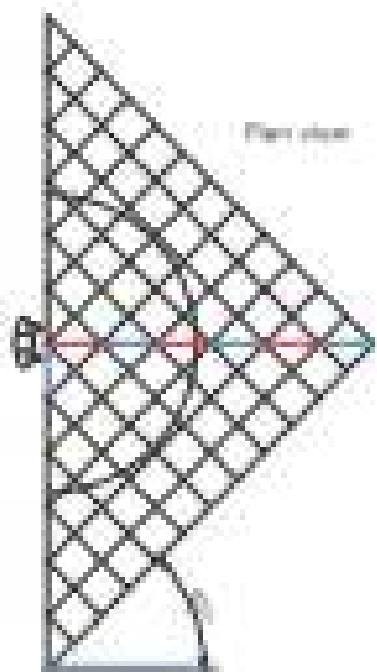


Convey a white green blue purple.
Let your love points off the vertices of the
rectangle and the 200-point corners with the
exception of the off diagonal corner and
the intersection of the two 200-point



Hemispherical field of vision PLATINUM Grid 48°

Perspective diagram



Plan view

Side view

Diagram with the CV-camera cutting the vertical Picture Plane.

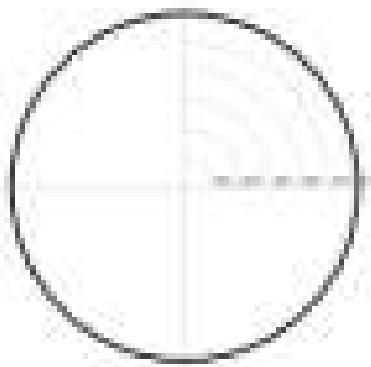
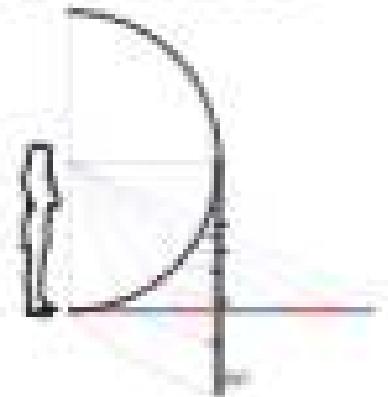
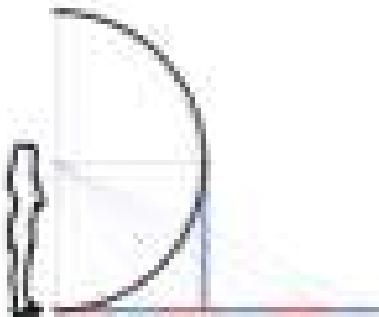
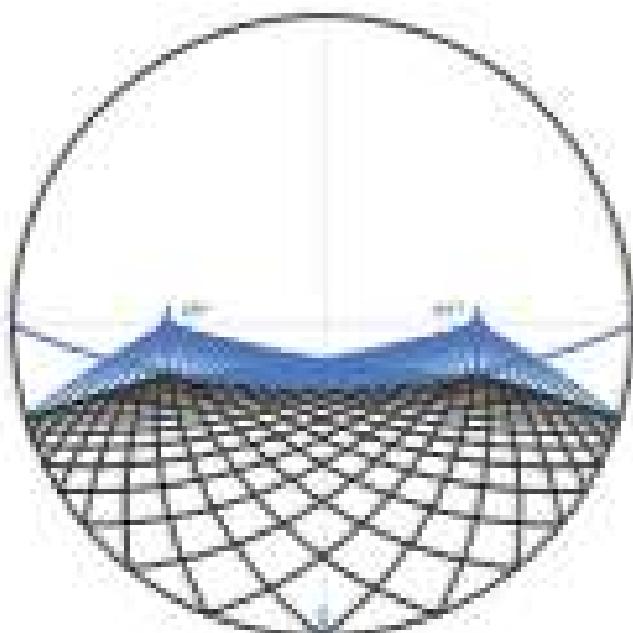
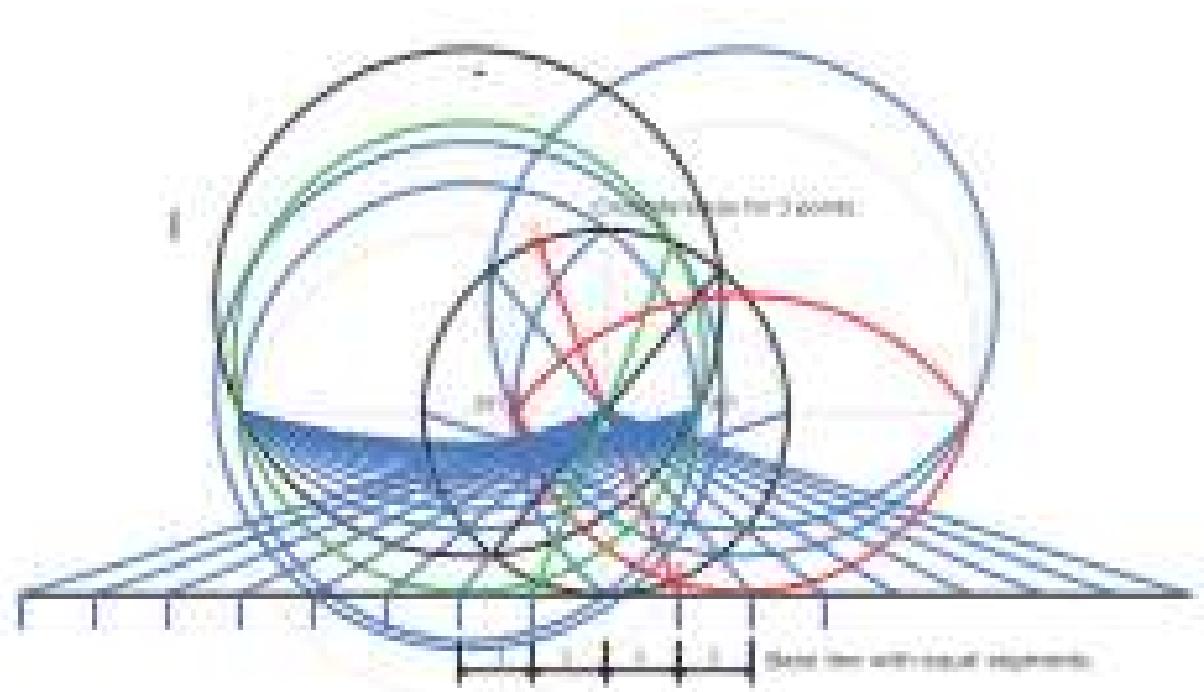
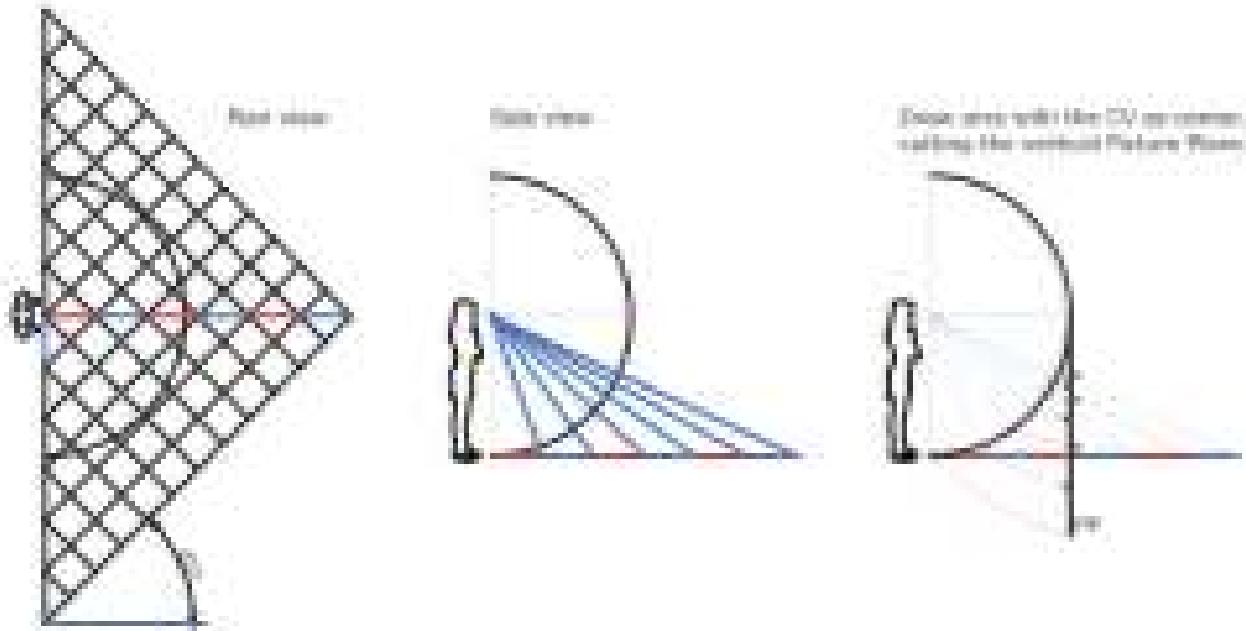


Diagram of arrangement of the optics in a hemispherical field of vision (patterned).

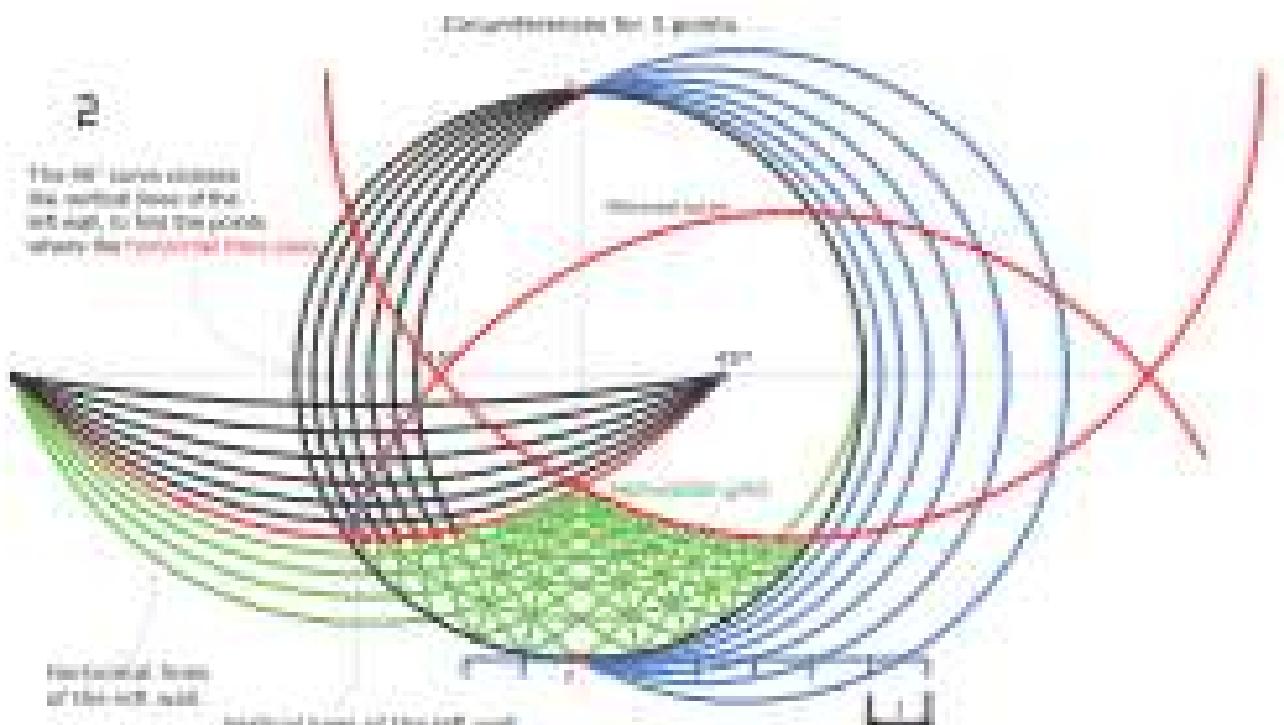


Complex perspective diagram.

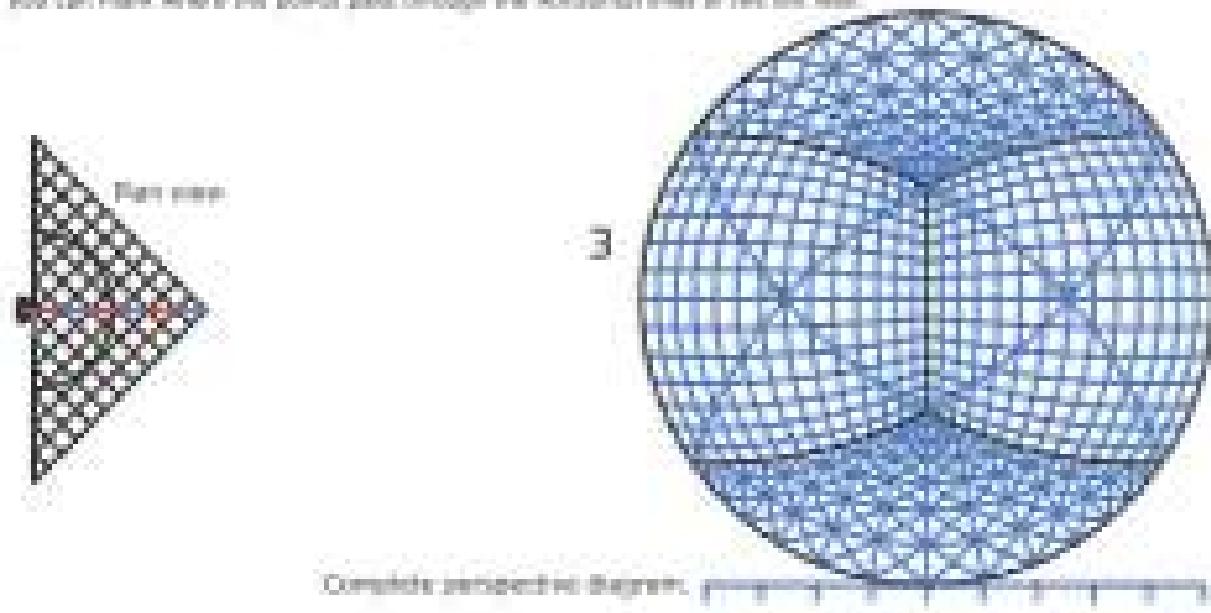
Hemispherical field of vision flattened grid 45°



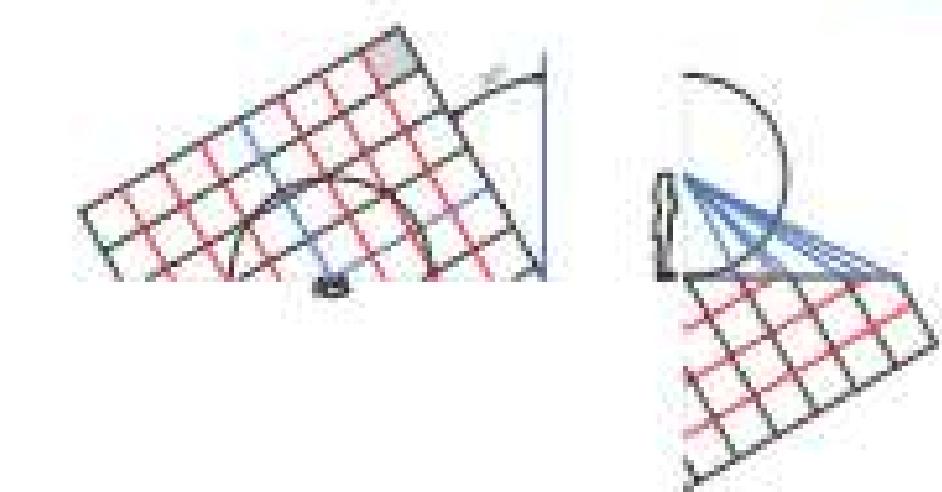
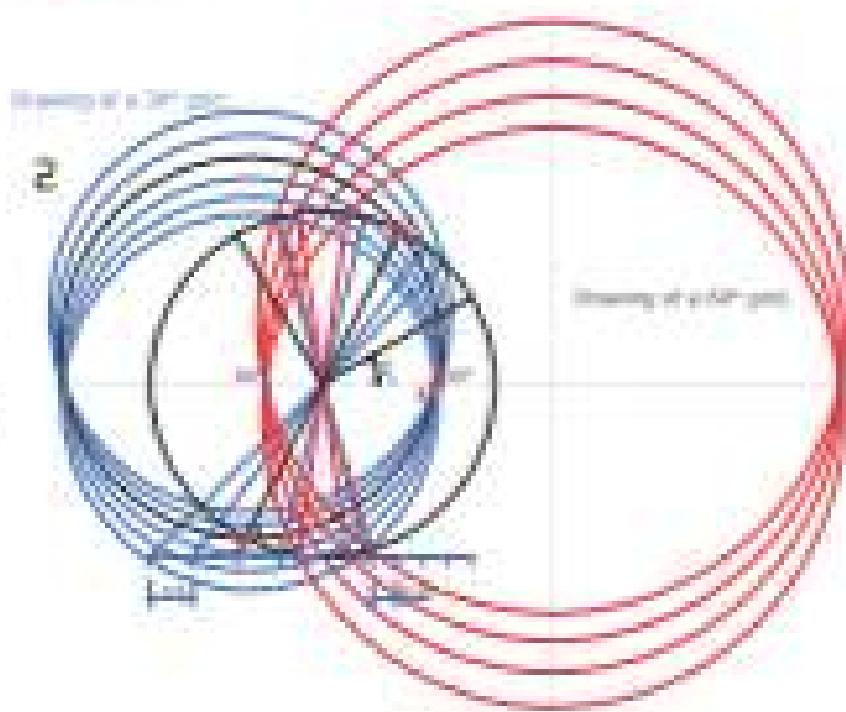
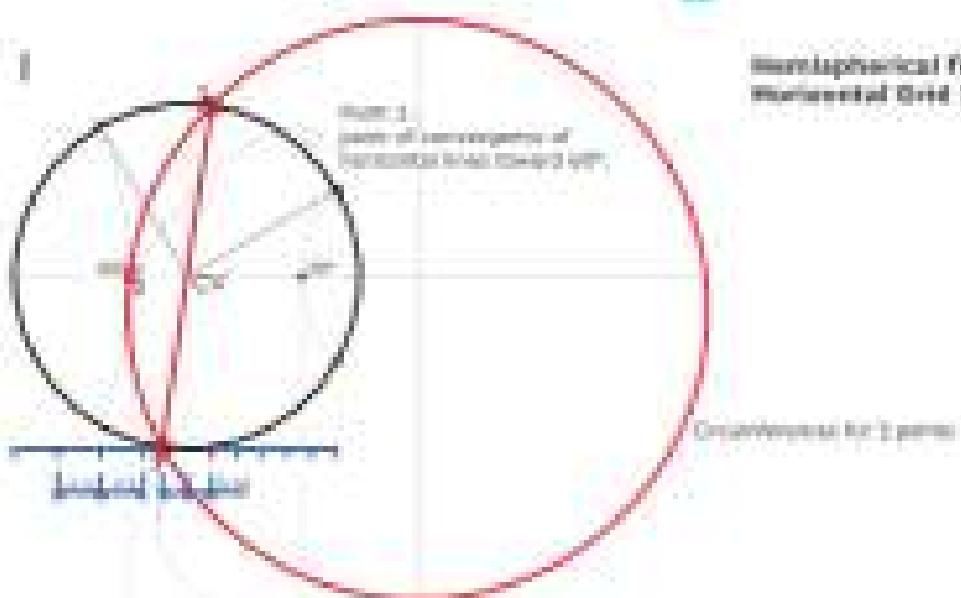
Hemispherical field of vision PLATTENED Grid 40°



- a - Drawing the horizontal grid.
- b - From the edge of the horizontal grid (labeled 2), draw a series of curves by these points (points 1-2-3).
- c - Anywhere on a line that puts the vertical axis of the eye to the left, you can mark where the colors pass through the horizontal lines of the left wall.



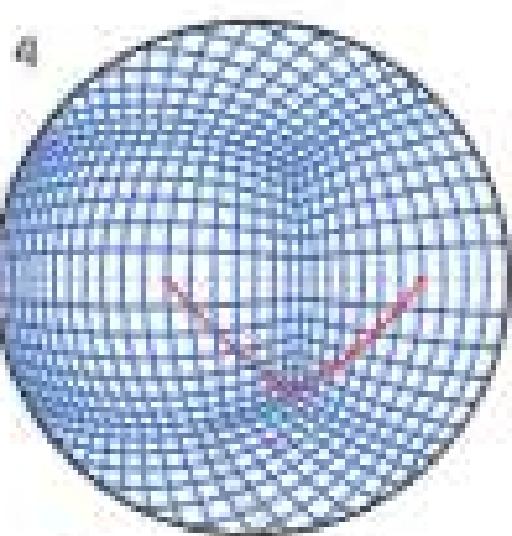
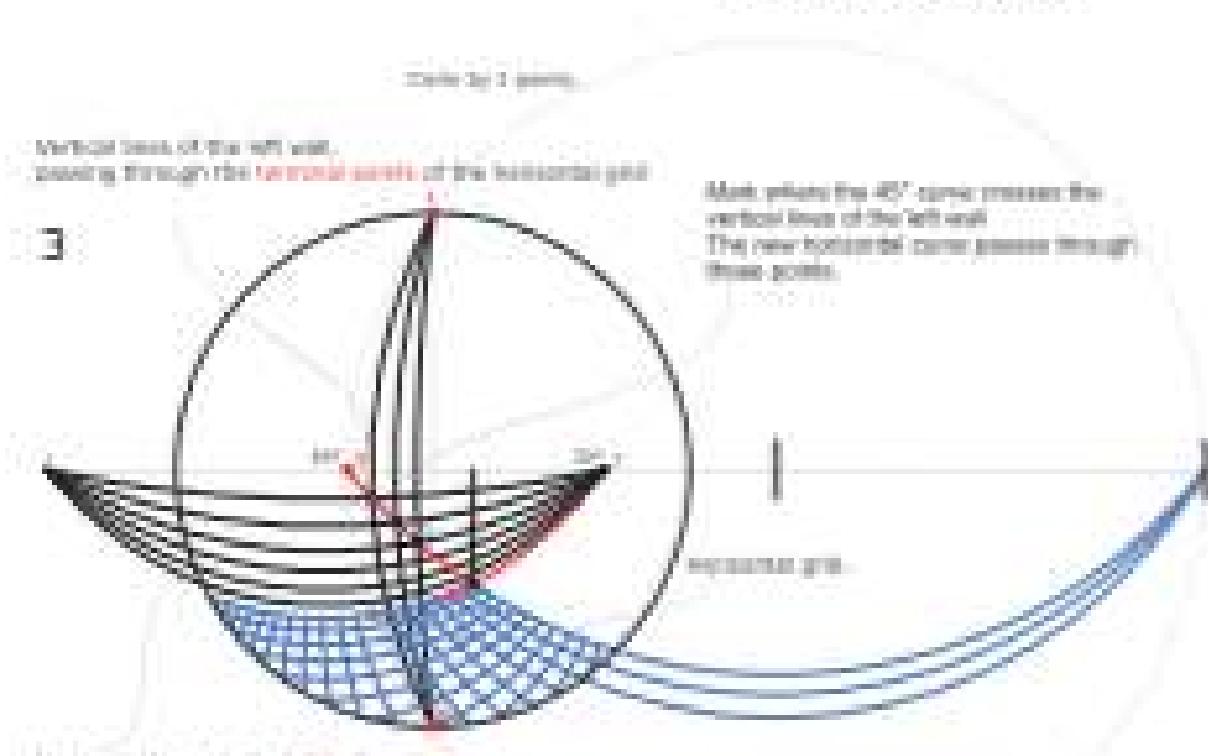
**Hemispherical field of vision PLASTERED
Horizontal Grid 30° / 30°**



Perspective diagram
of the horizontal grid

The selected dimensions of the grid should be repeated on the baseline.

Hemispherical field of vision FLATTENED Horizontal Grid 30° / 60°



www.3dtotal.com/tutorials/3d-modelling/100-perspectives/003.htm

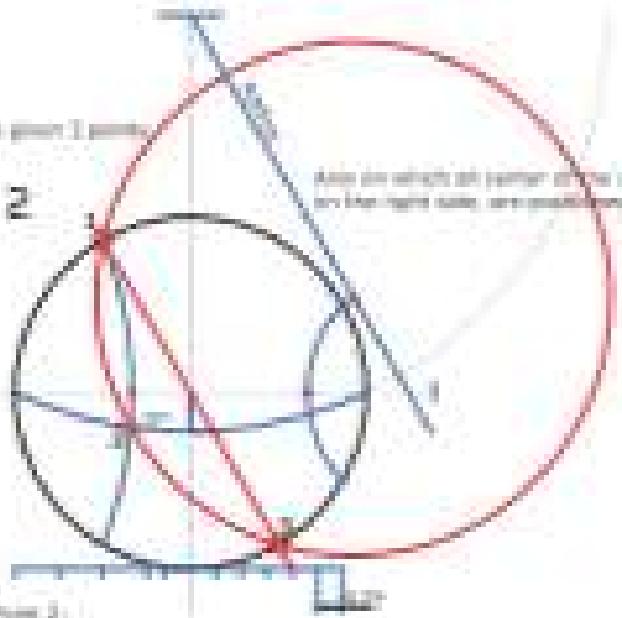
Multiaxial field of vision PLASTERED
Horizontal Grid 30° / 30°
Tilted 20° downward



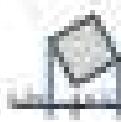
Diagram 1

Project a point given 3 points.

2



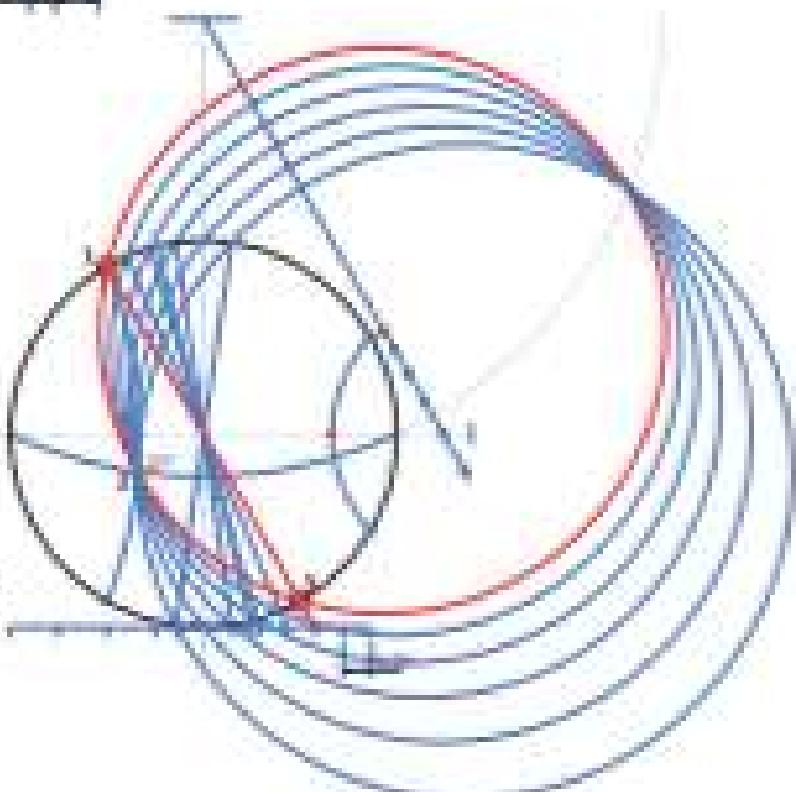
Point 3:
Convergence point of the two lines from the left and right 30° converges.



The projected dimensions of the grid images must be marked on the baseline.



3



Hemispherical field of vision (FLATTENED)
Horizontal 0-180° / 0-180°
Tilted 20° downward

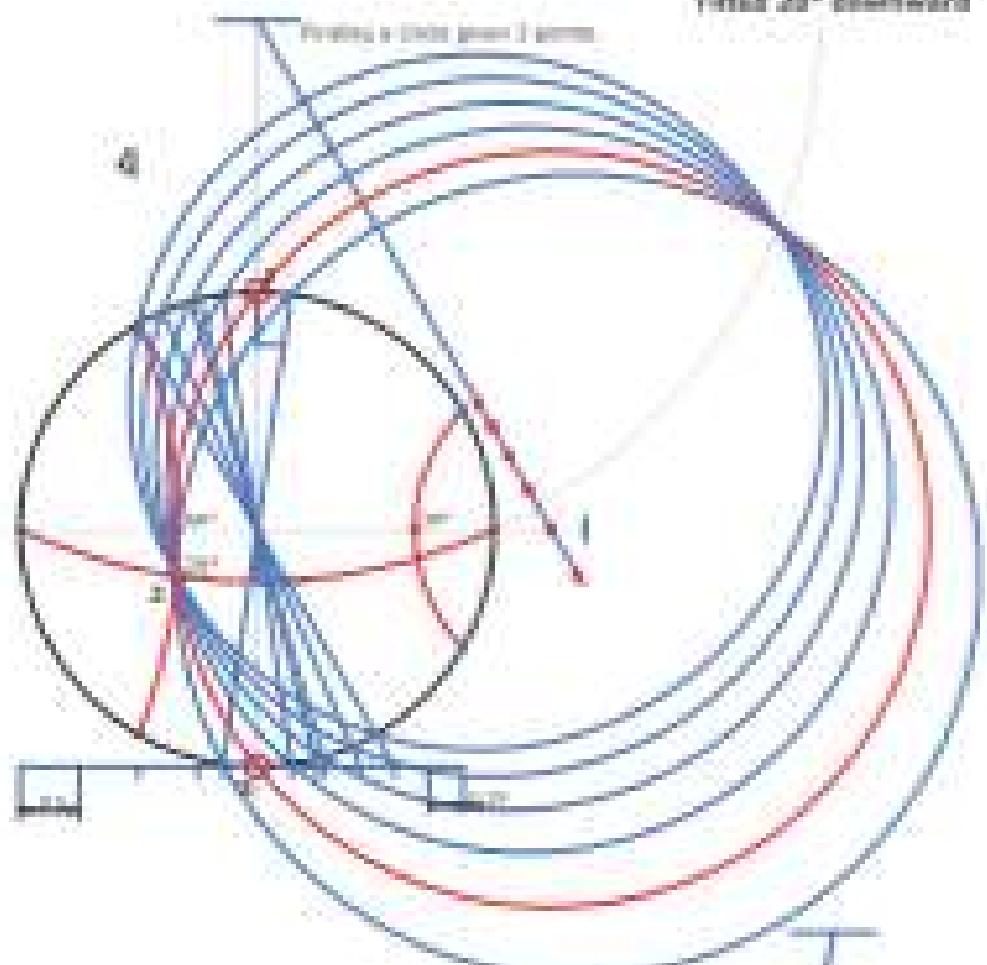
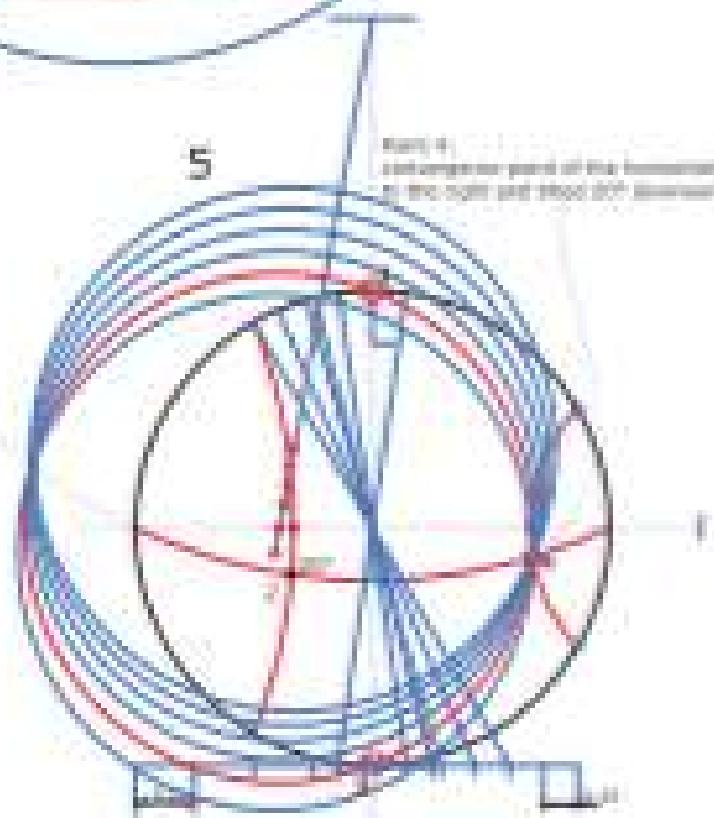
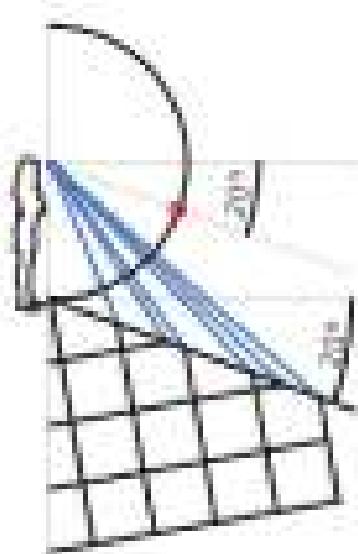
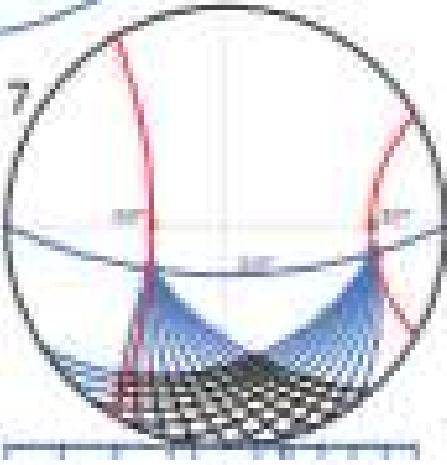
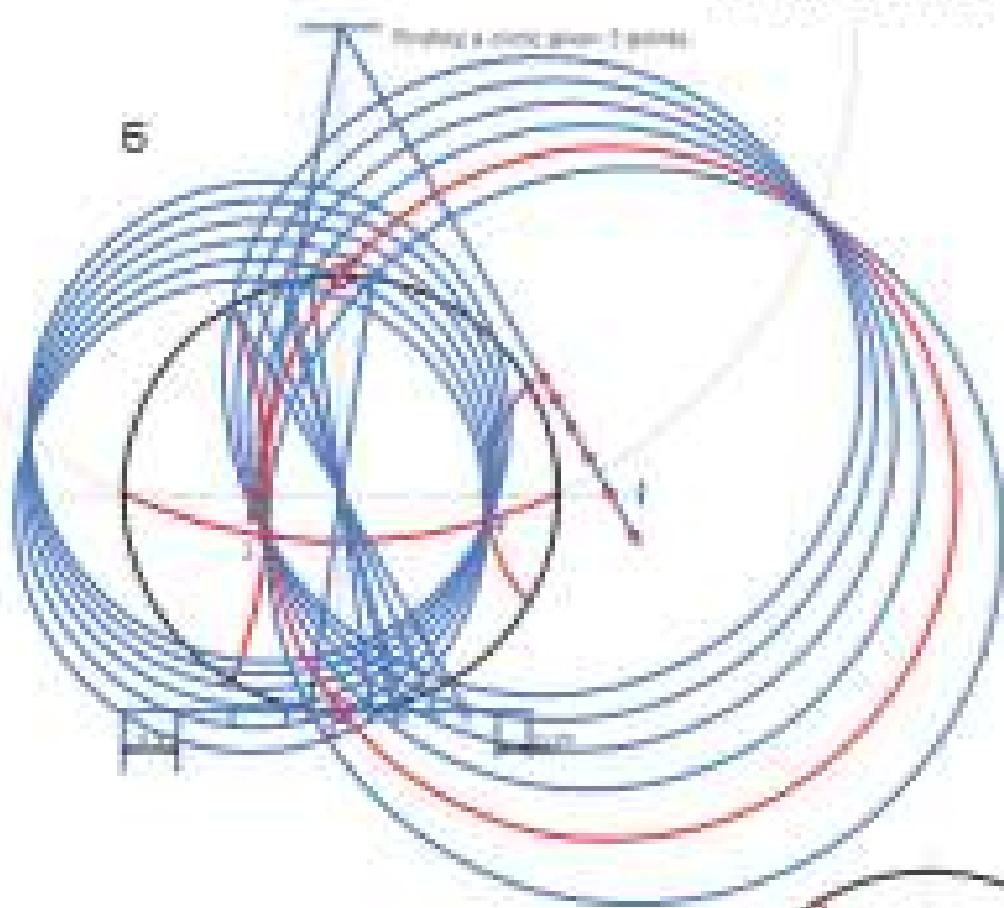


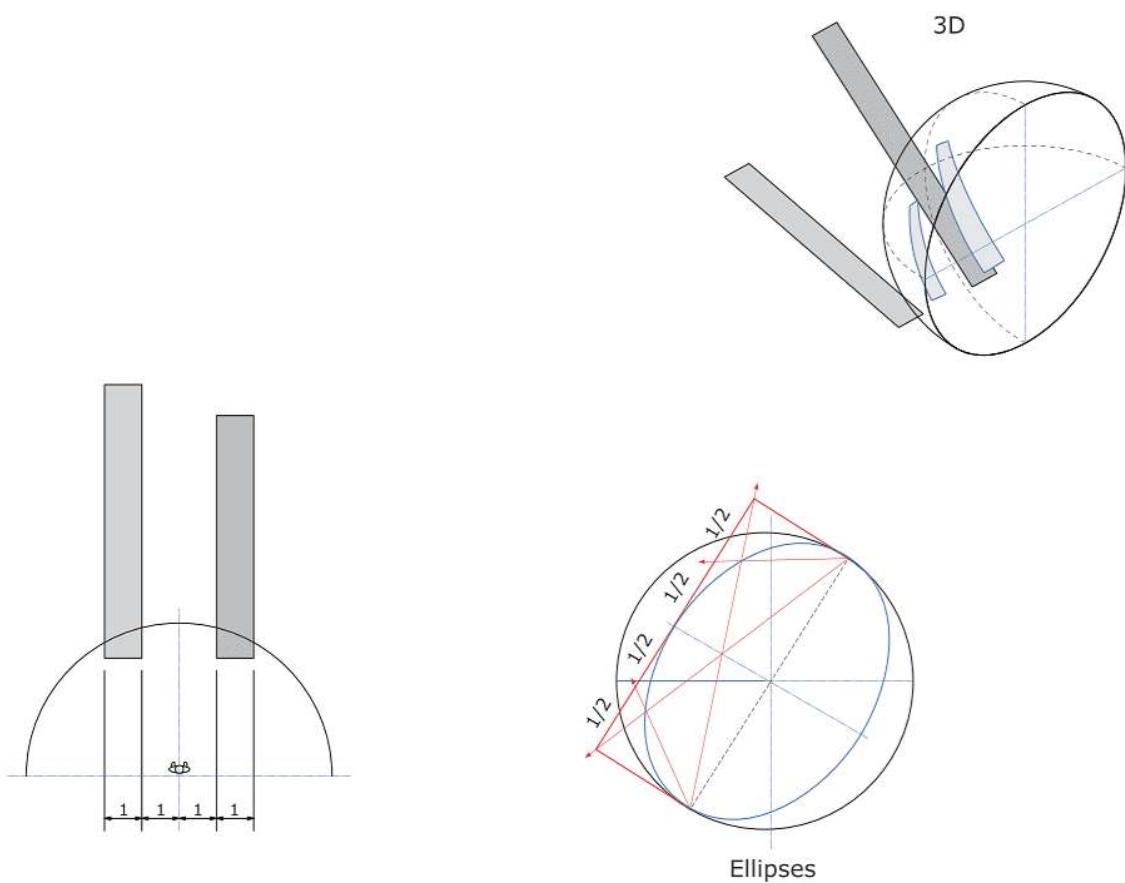
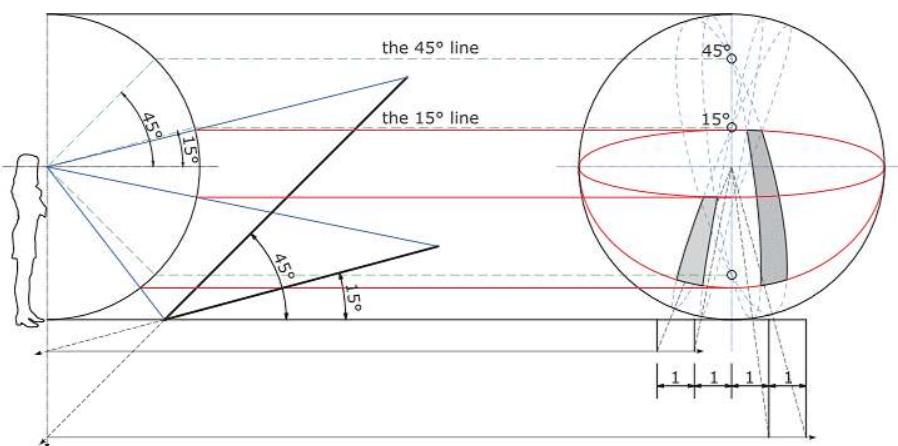
Diagram 4:
A hemispherical field of view (FLATTENED)
Horizontal 0-180° / 0-180°
Tilted 20° downward



Multiaxial field of vision PLASTENED
Horizontal Grid 30° / 30°
Tilted 20° downward

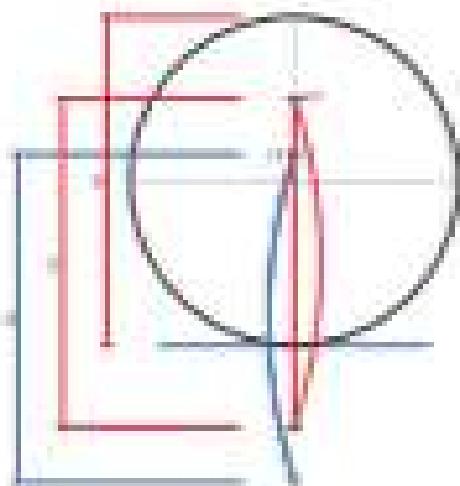
E



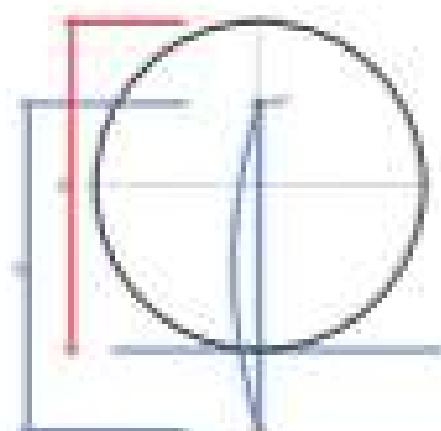
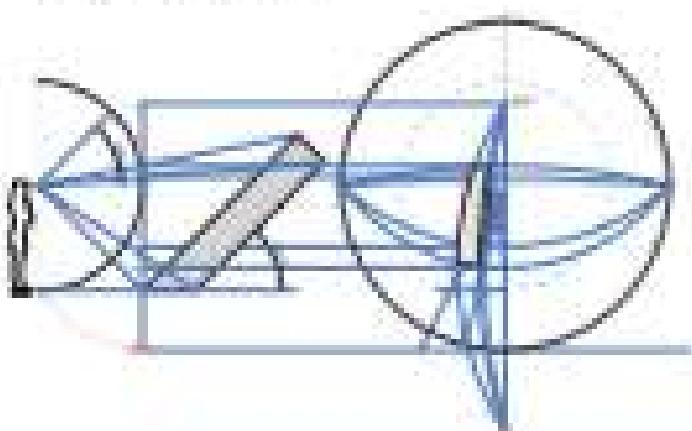
Hemispherical field of vision CURVED**Frontal inclined planes**

Hemispherical field of vision PLATTENED

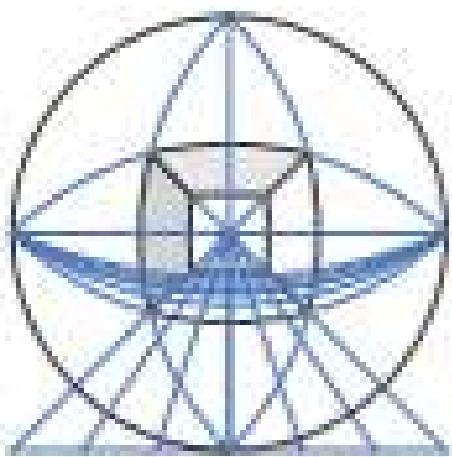
Frontal inclined planes



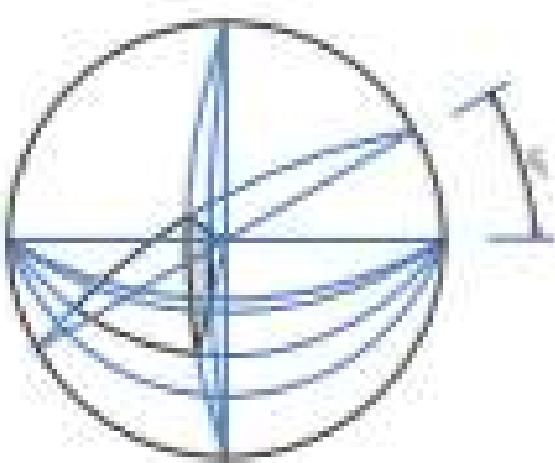
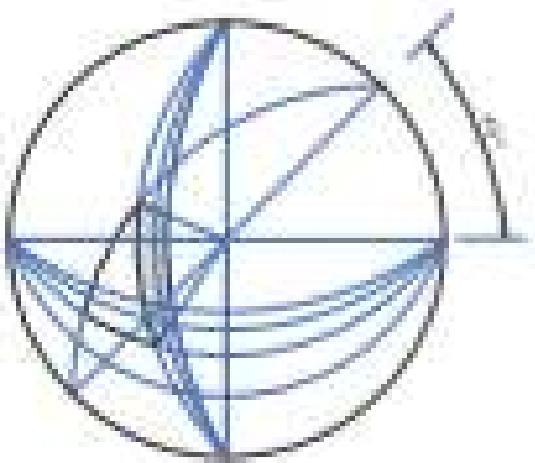
Frontal inclined axon.



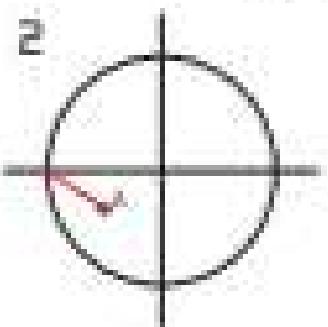
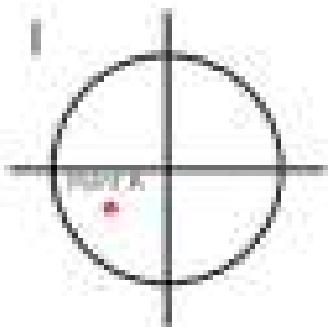
Hemispherical field of vision PLATE 88



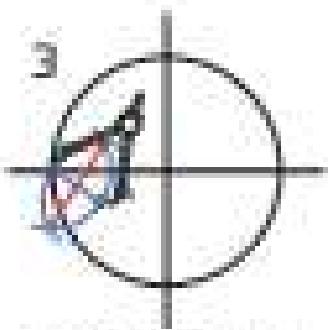
Turn the handle to rotate the sphere so you can view related objects on adjacent plates.



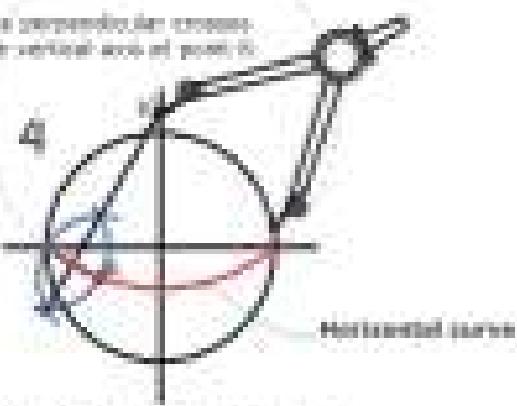
Construction, with the use of a compass, of a passing through a particular point



The perpendicular crosses
the vertical axis at point A.

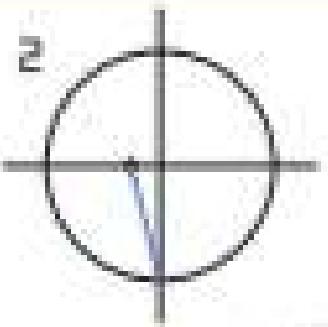
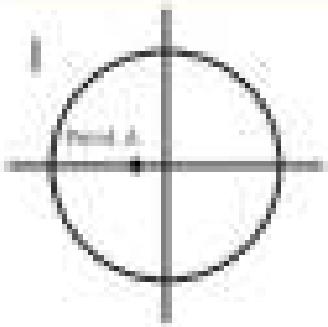


Draw the perpendicular

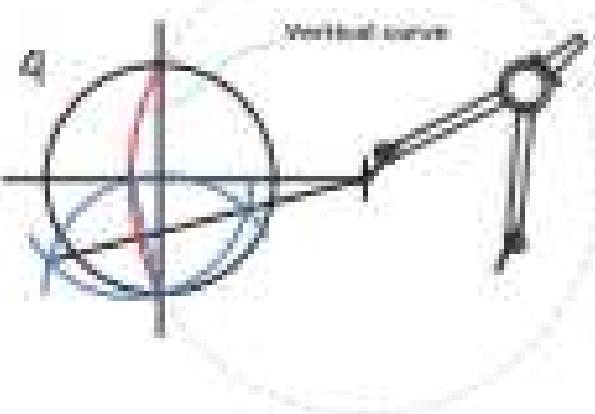
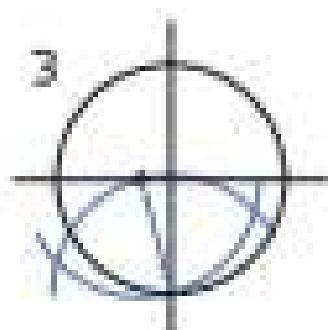


Horizontal curve

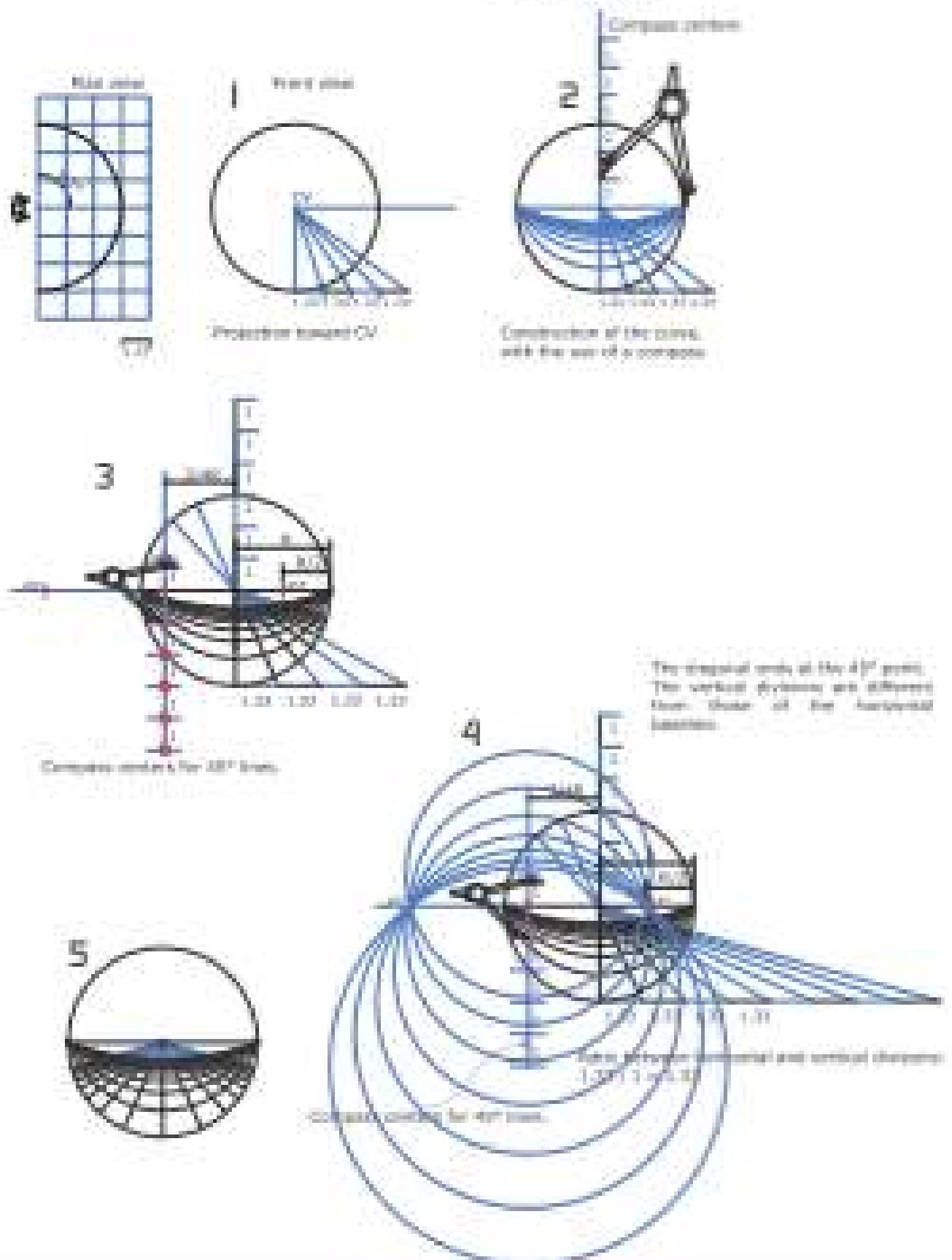
Place the compass on point A and
draw an arc passing through point B



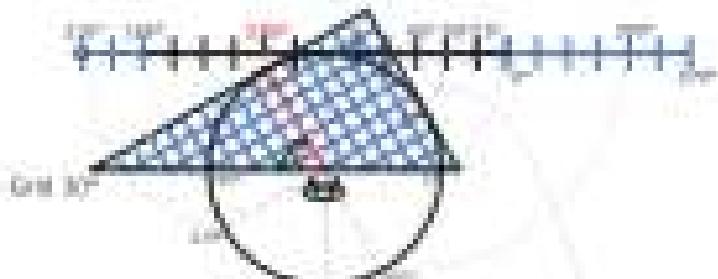
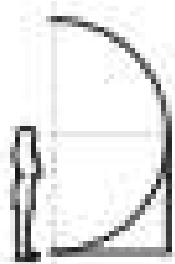
Vertical curve



**Hemispherical field of vision FLATTENED
Grid 90°
Easy version**



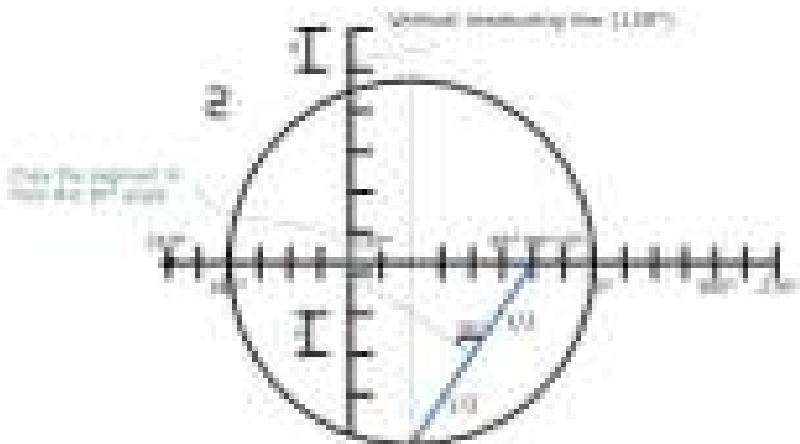
**Binocular field of vision PLATTNER
Grid 30°/30°**



The visual receptive fields are positioned at the points corresponding to the midpoints of the edges of the binocular field of view (30° × 30°).



The intersection of the visual fields is situated along the optical axis, since all the visual elements project onto one point.

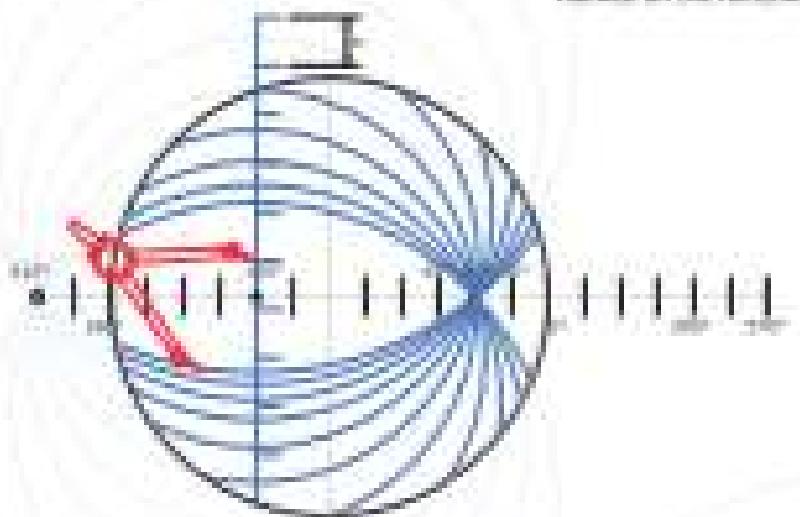


a

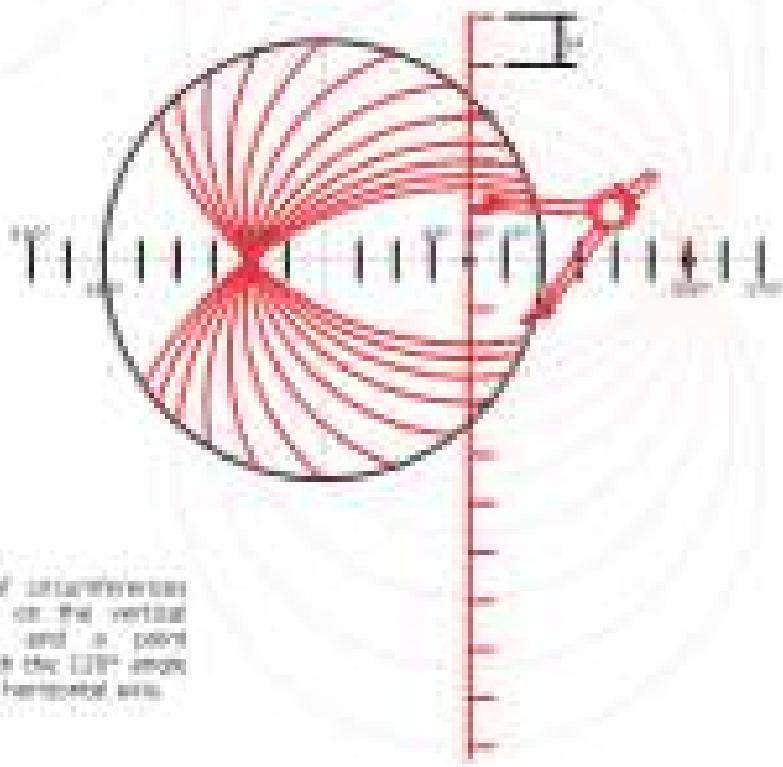
Hemispherical field of vision PLATTNER
Grid 30°/30°

3

Construction of hemispheres with centers on the vertical meridian line and a point passing through the 30° angle marker on the horizontal axis.



4



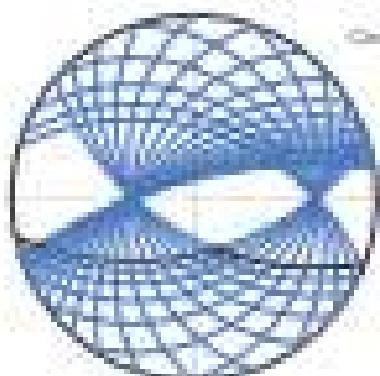
Construction of hemispheres with centers on the vertical meridian line and a point passing through the 120° angle marker on the horizontal axis.

binocular field of vision PLATTNER

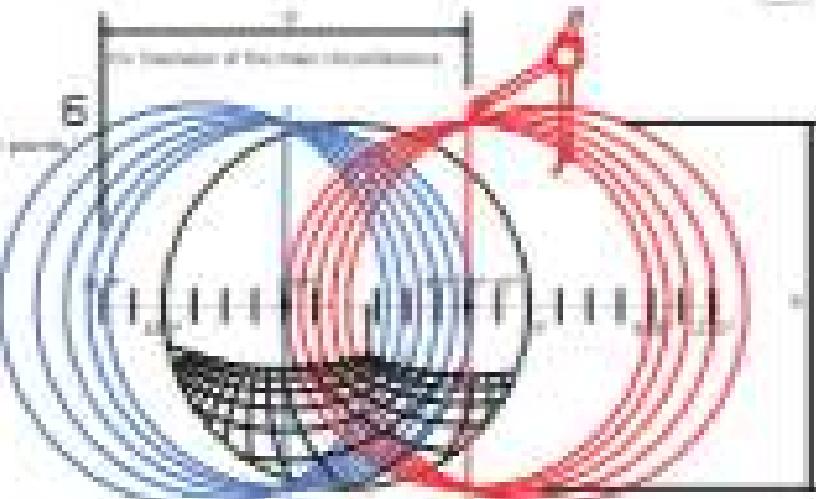
width 35° / 50°

E

5



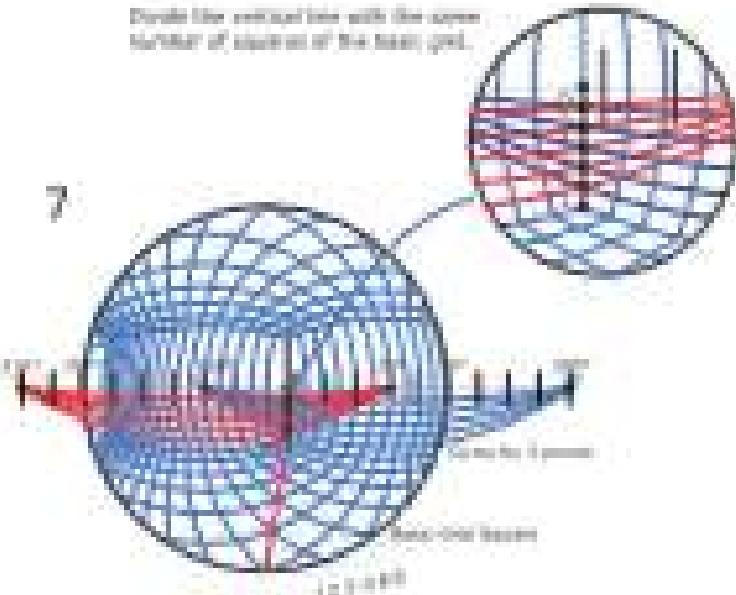
Binocular field



Visual axes

Binocular field
All and individual arc sections of the visual periphery they form the binocular field of vision of the visual field.

7



Visual axes

Binocular field
Left and right eye's periphery of the binocular angles and the binocular zones are the common free vision periphery parts, corresponding to the number of the visual field supports.

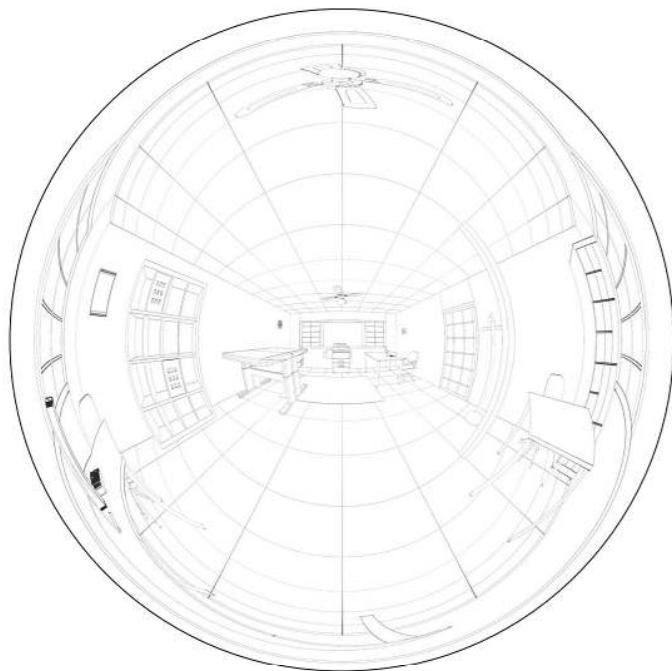
8



Binocular field

6 vanishing points

Spherical perspective



6-point perspective

Spherical field of vision

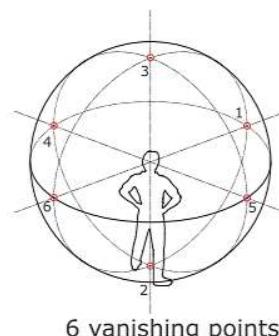
The difference between curved or flattened spherical perspective corresponds to the difference between world globe and planisphere:

in the first case, the drawing is represented on a three-dimensional sphere, in the second case, the drawing is projected onto a two-dimensional sheet.

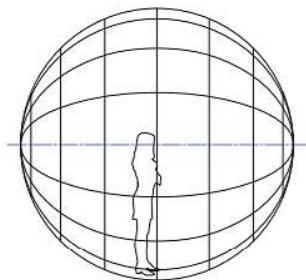
This projection of the sphere on a two-dimensional plane involves the application of mapping techniques with different levels of distortion.

The unfolding and flattening of the sphere on the plane inevitably leads to distortions.

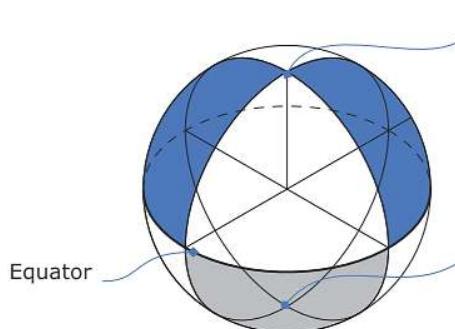
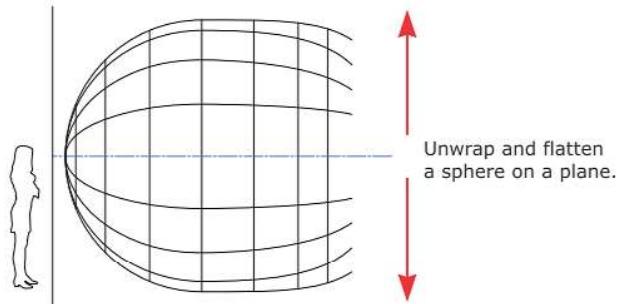
For this reason, it is preferred to project the spherical visual field on the cylinder, as this is easier to unroll on the sheet.
(See below Projection Equirectangular)



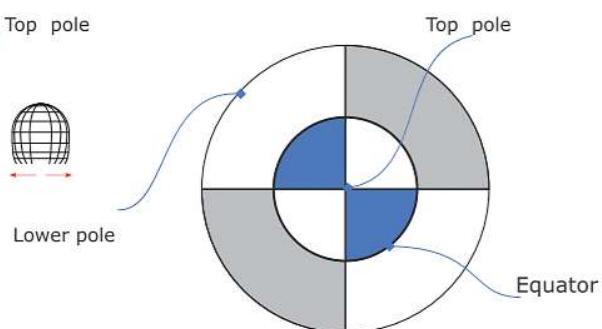
Spherical field of vision



Flat sheet



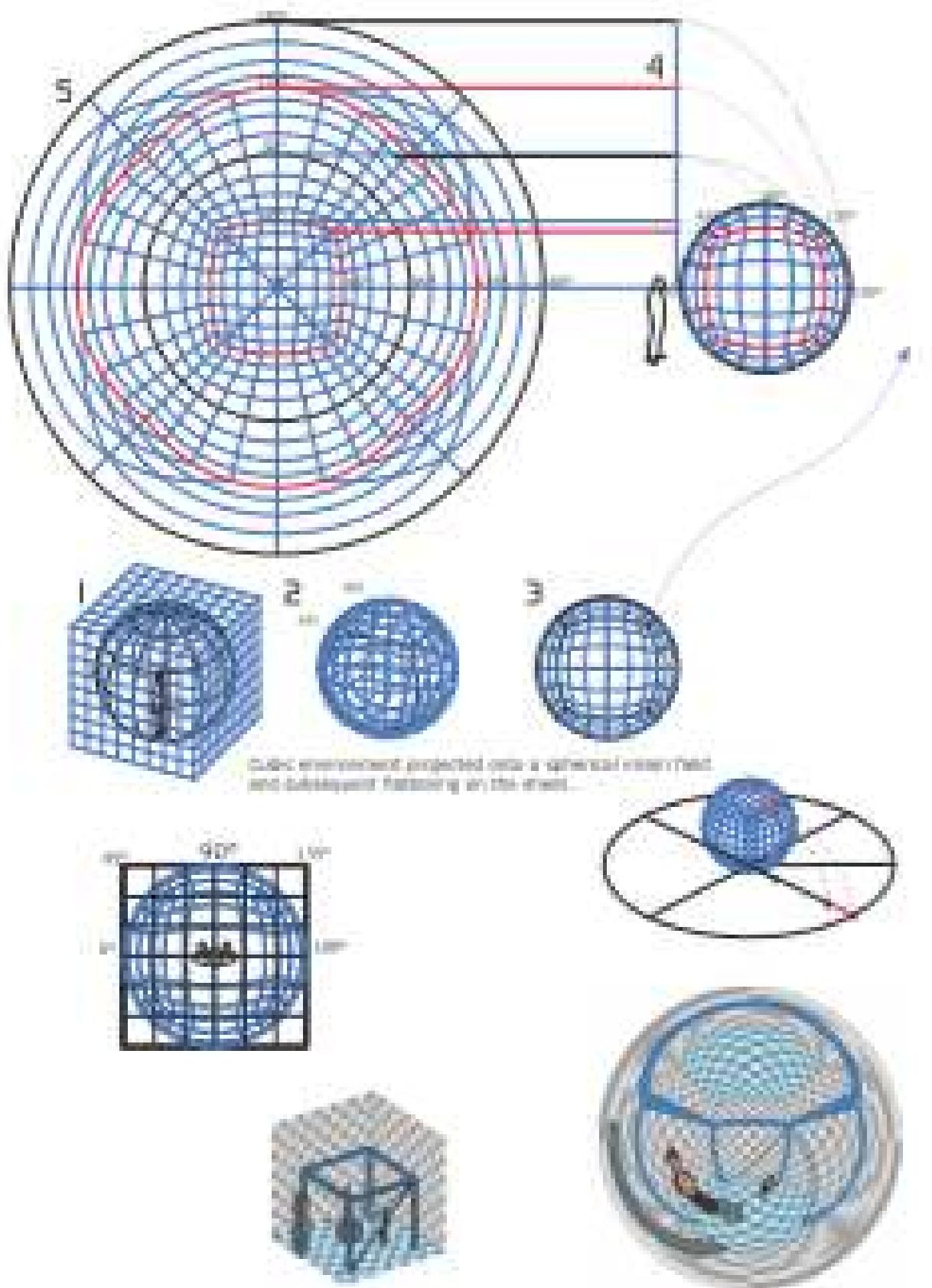
Three-dimensional view



Projection on a flat sheet

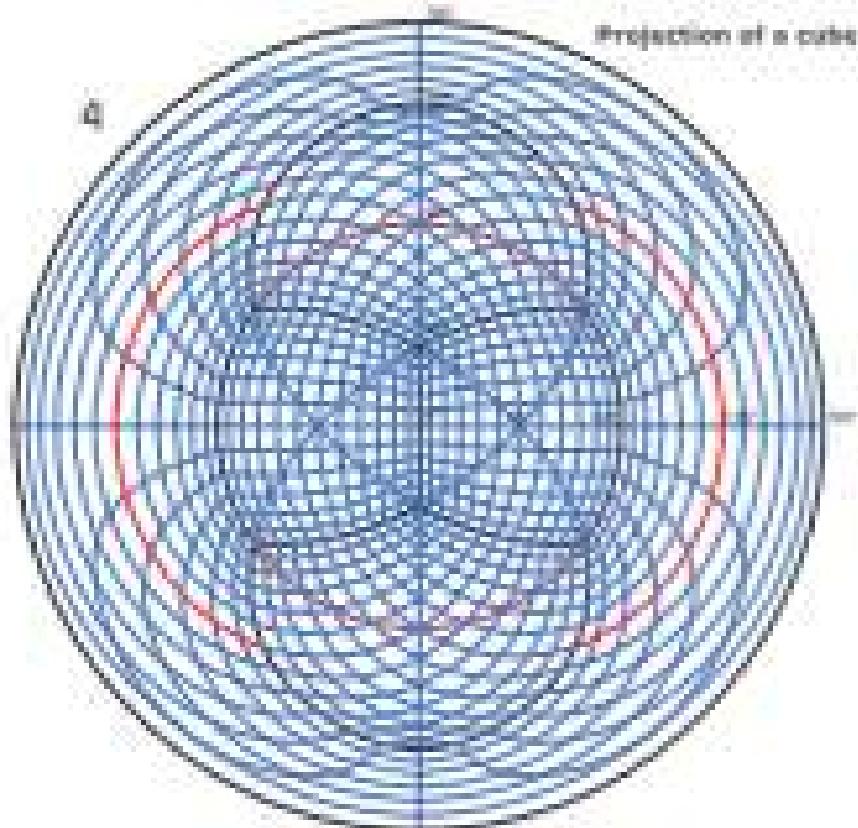
Projection of a cube on a spherical field of vision

Spiral 1997



Projection of a cube on a spherical field of vision

David Gurn



Cubes are drawn with projected wireframe spheres onto their visible faces and subsequent partitioning on that sphere.

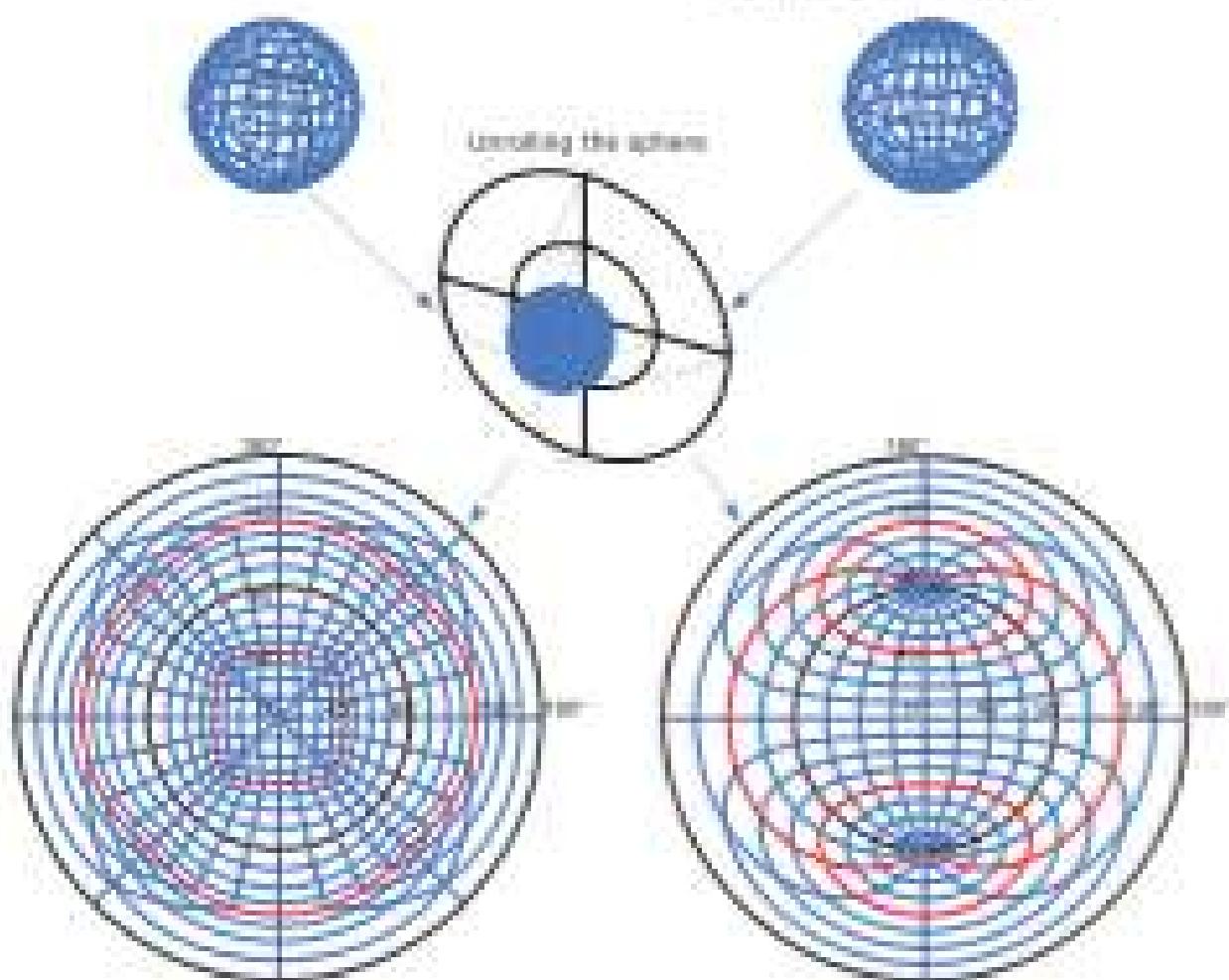


Spherical visual field



• Unrolling Paths

Cubes projected on a spherical visual field

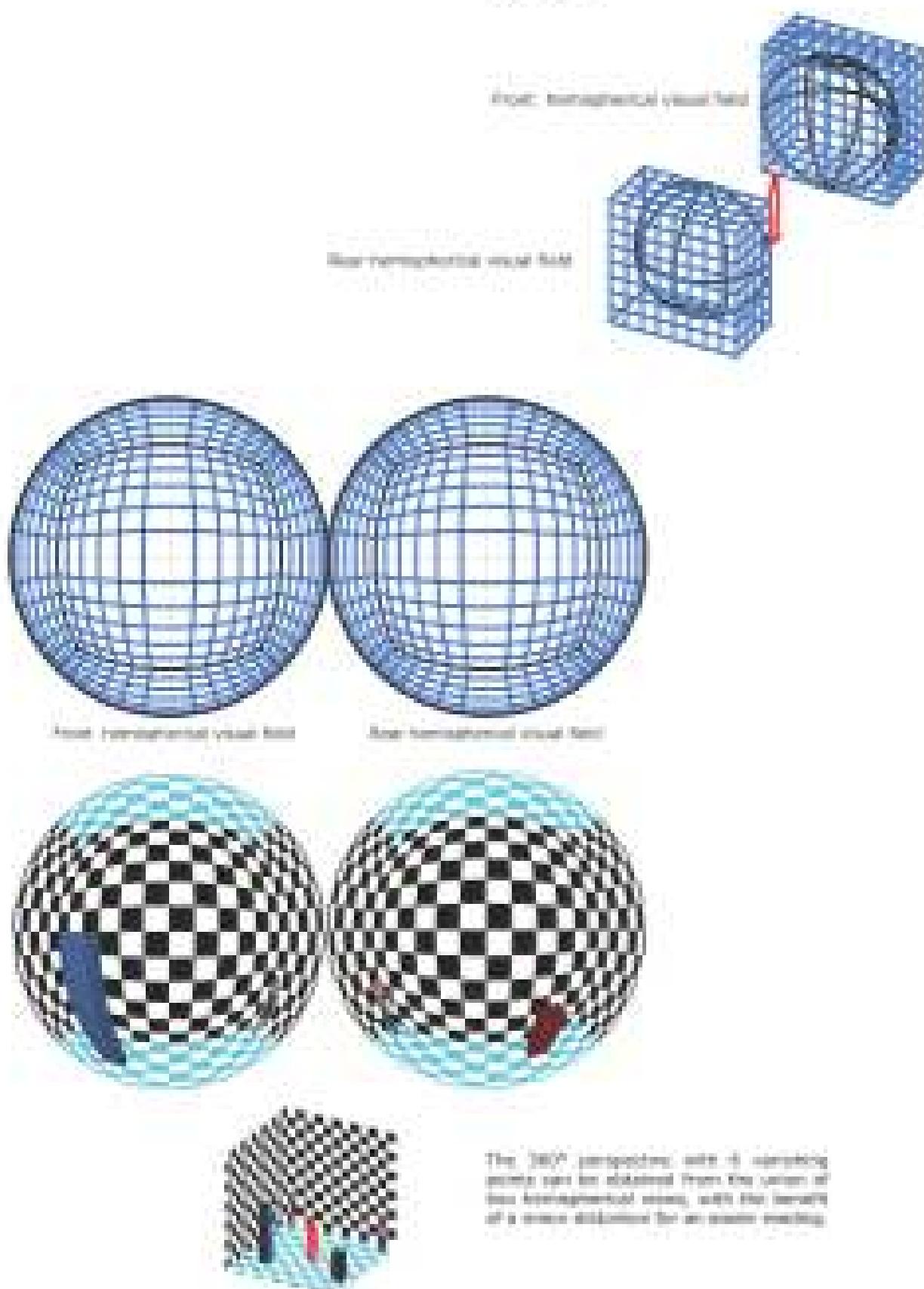


• Cube components projected onto the spherical field of vision and unrolled onto paths on the plane.

Meridians and parallels projected on spherical visual field

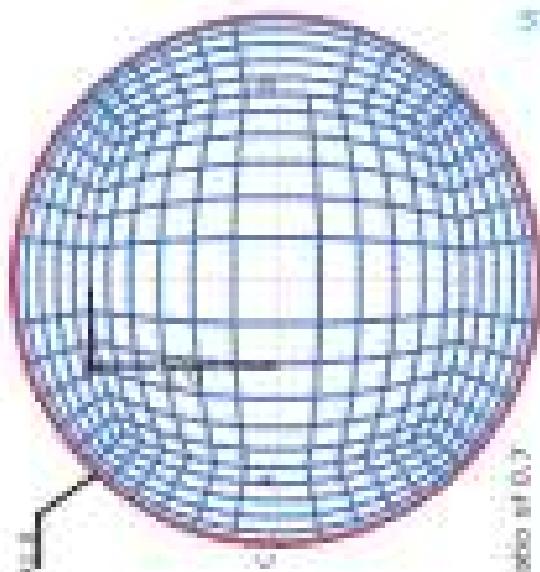
• Patterns formed by meridians and parallels projected onto the spherical field of vision and unrolled onto paths on the plane.

Projection maps on a spherical field of vision split in half



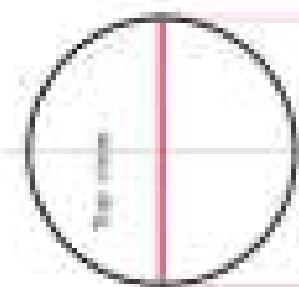
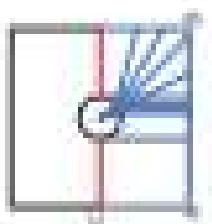
UNIPOLAR

Refractive sphere in a cubic environment

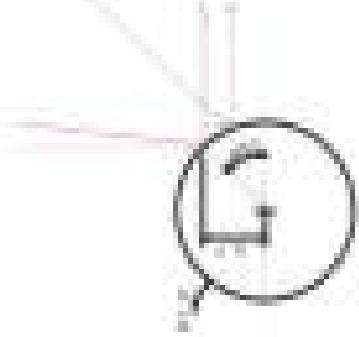


57

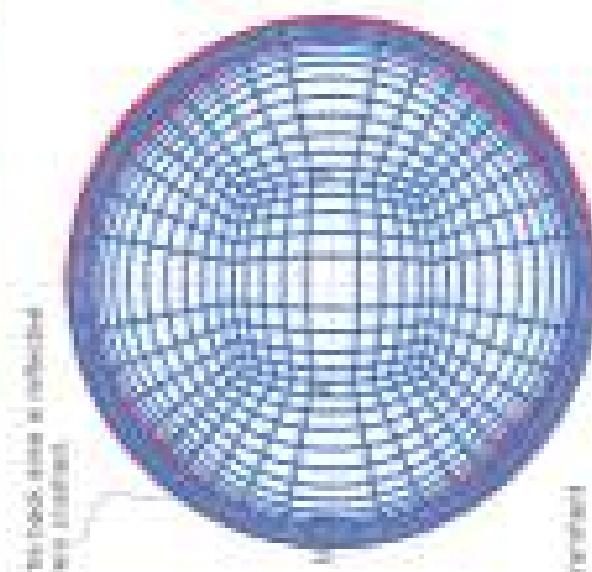
$D = 1 \times \text{voxel size} = 0.5$



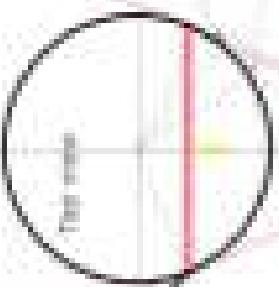
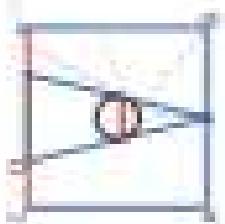
Directional reflection
from one side of the sphere



For the first iteration, each cell has a fixed value for the refractive index. This value is determined by the average refractive index of the entire cell. Although this is a very simple way to calculate the refractive index, it is not very accurate. It is also very slow, as it requires calculating the average refractive index for every cell in the volume.



Refractive sphere in a cubic environment

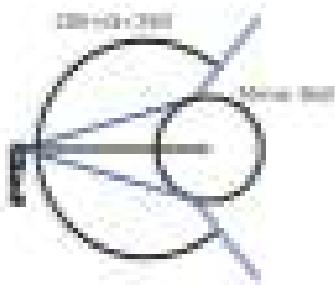


For the first iteration, each cell has a fixed value for the refractive index. This value is determined by the average refractive index of the entire cell. Although this is a very simple way to calculate the refractive index, it is not very accurate. It is also very slow, as it requires calculating the average refractive index for every cell in the volume.

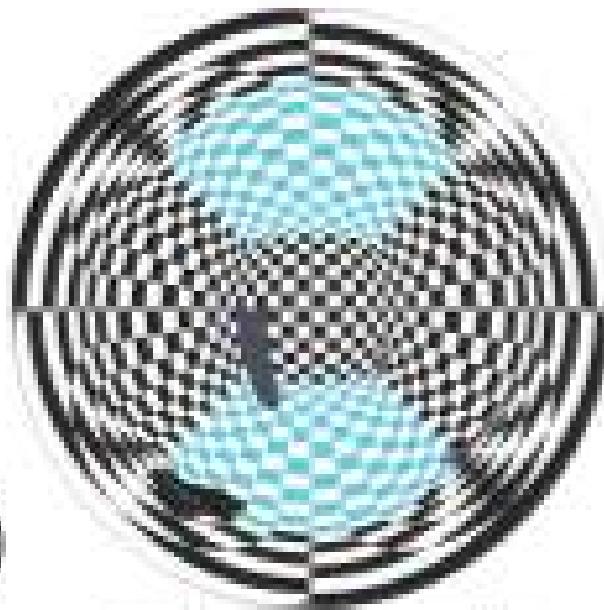
Comparison table for different perspectives



Reflecting Sphere
Visual field: 180° and 360°



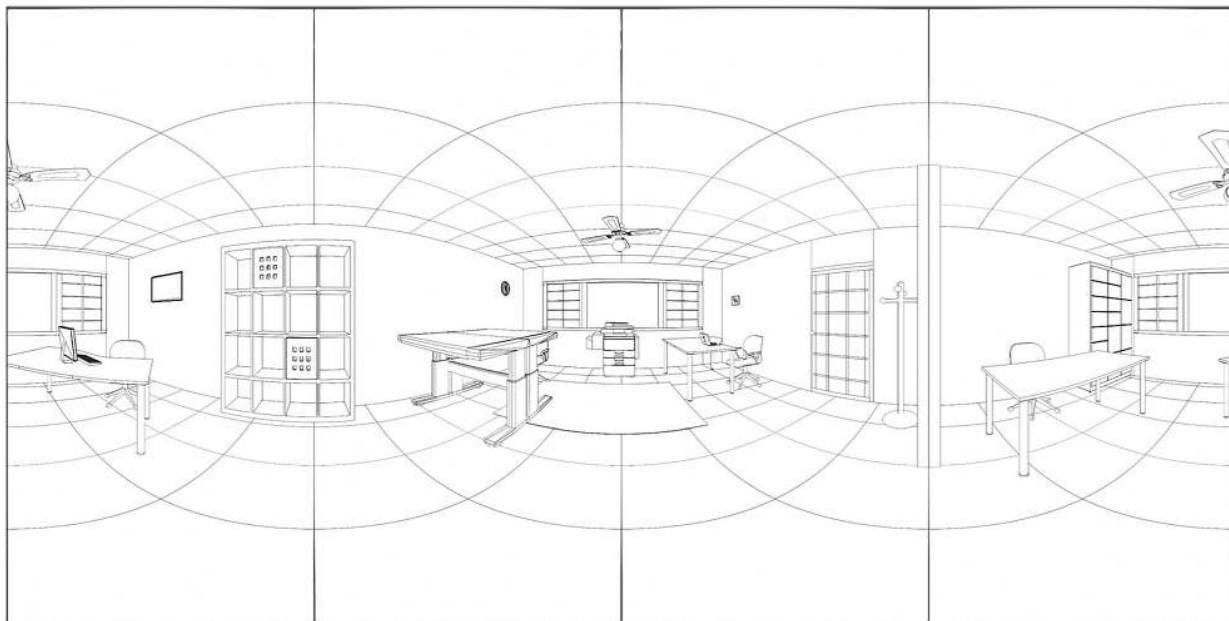
3-point curvilinear perspective
(180° visual field)



3-point curvilinear perspective
(360° visual field)

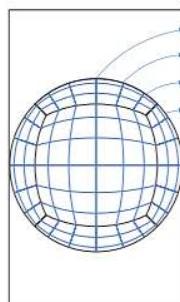
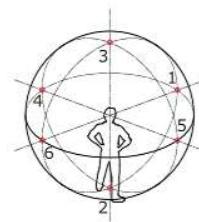
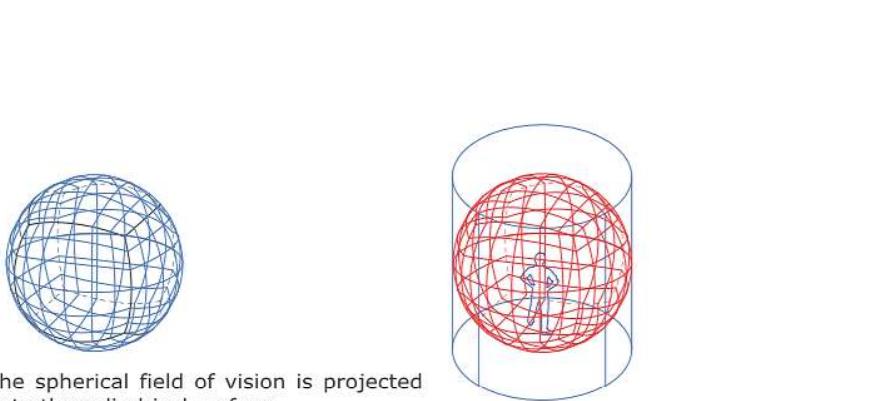
6 vanishing points

Cylindrical perspective

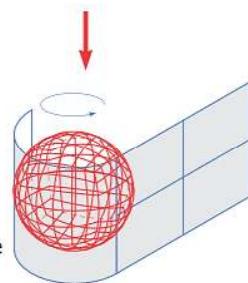


6-point perspective - Equirectangular projections

Projection of a spherical field of vision

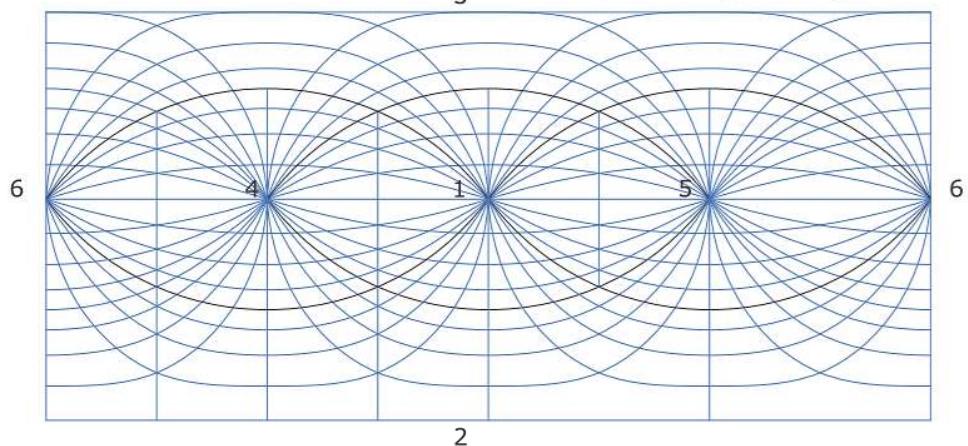


Equirectangular cylindrical projection

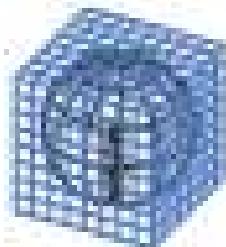


Unrolling a cylindrical surface onto a plane

Equirectangular Projection

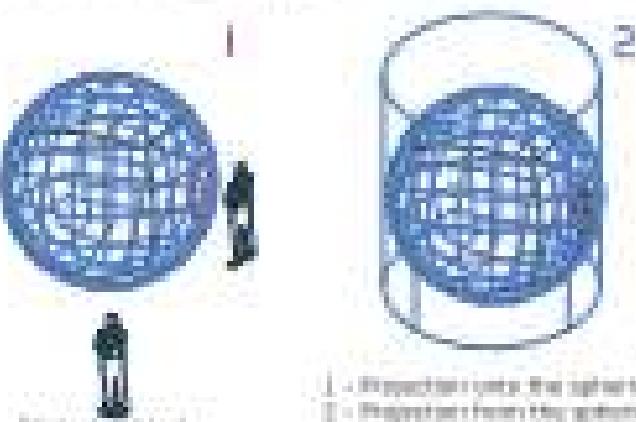


Cylindrical perspective from spherical projection

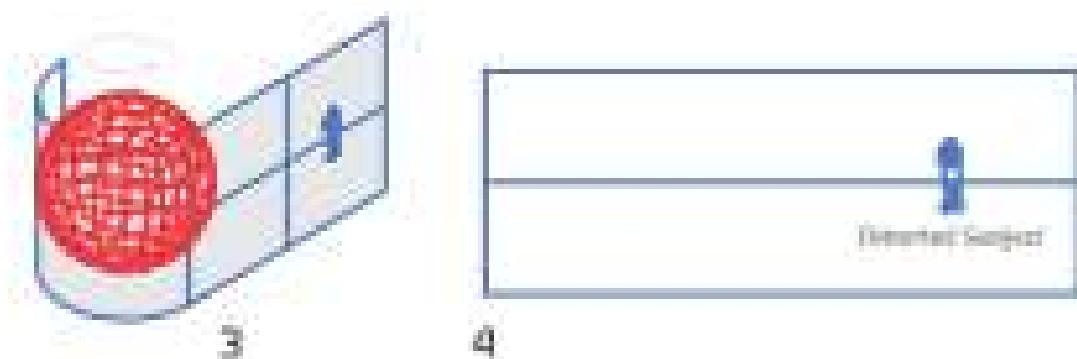


Projection of an object
onto the cylindrical surface

Projection of the spherical field of vision
onto the cylindrical surface.



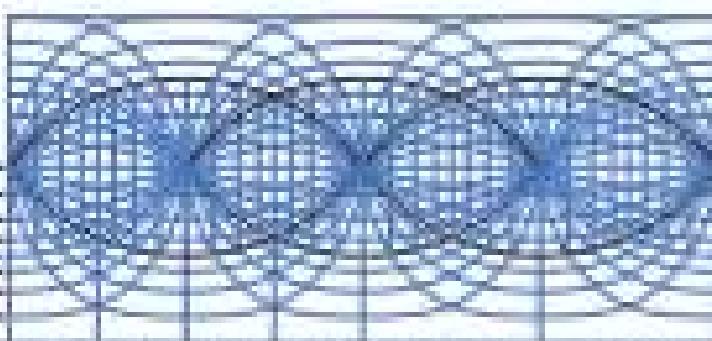
- 1 - Projection onto the spherical surface;
- 2 - Projection from the spherical surface onto the cylindrical surface;
- 3 - Drawing of the cylindrical surface;
- 4 - Drawn subject.



Rectangular perspective



Grid of the cube

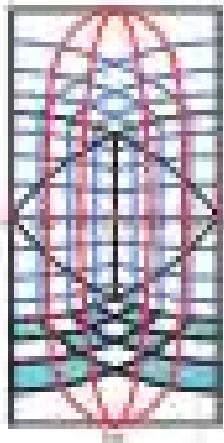


The drawing on the sphere is curvilinear to form an oval, but if you project it onto the cylinder this can be mapped and stretched, generally a perspective view is rectangular.

Bottom point by point of a spherical projection on the parallel cylindrical surface.

Horizontal angles

Scanning points after
removal process



many of contact with
the visual field

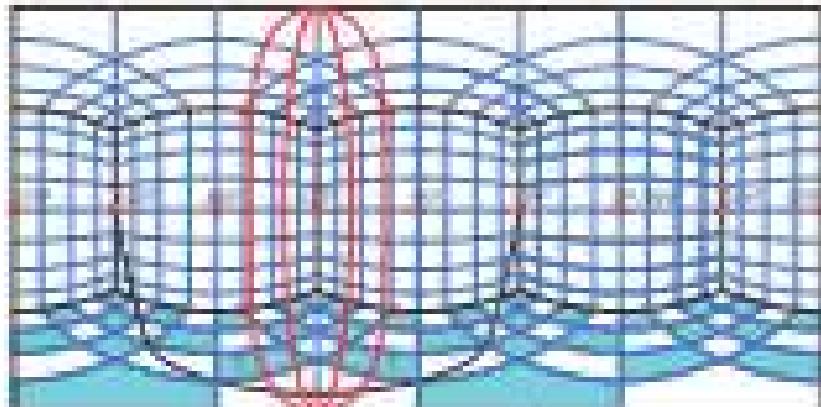
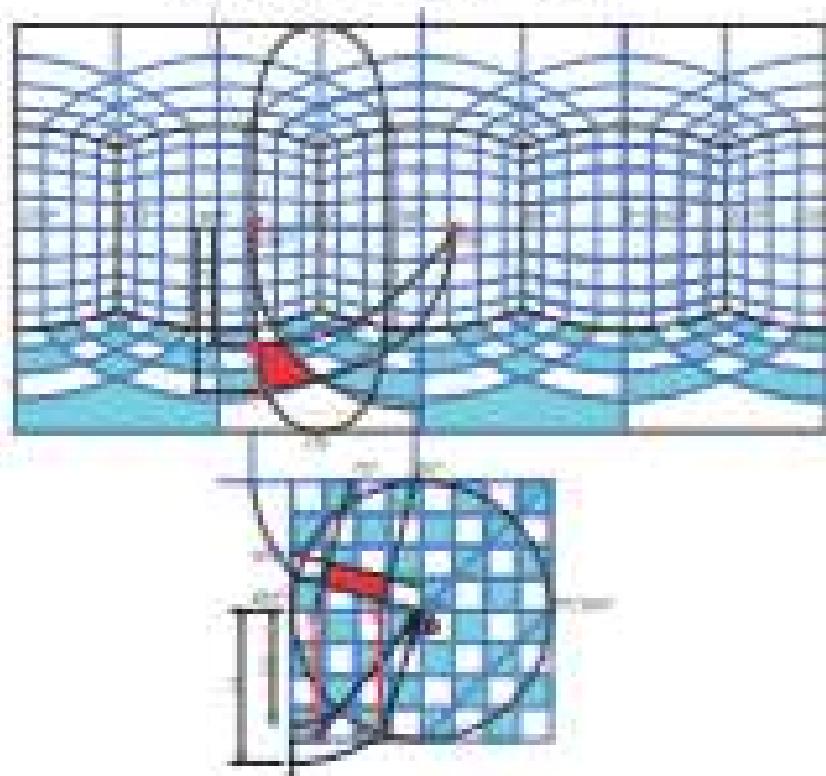


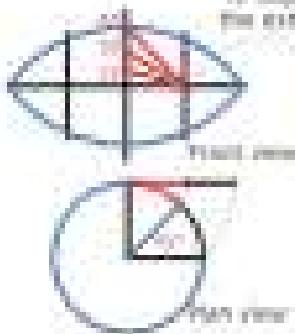
Diagram with no points
inside the visual field

The two parallel sides of the rectangle converge
progressively to the same vanishing point

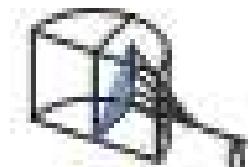


Vertical angles

45-degree angles from the exterior surface.

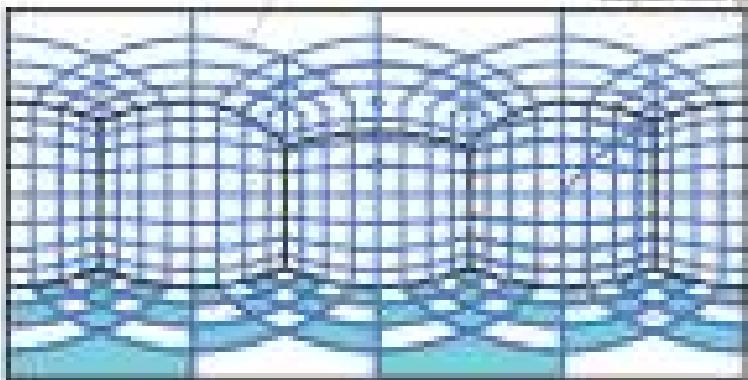


3D volume

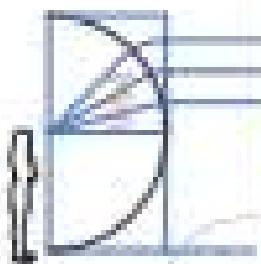
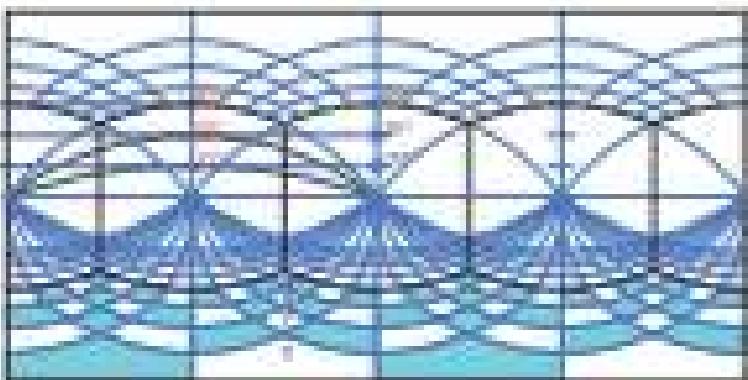


This angle are measured from the point at 45° of the overall pyramidal surface.

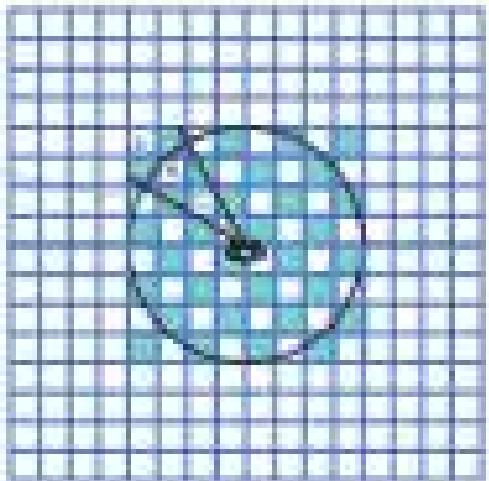
Slope angles



The grid looks like it's represented in a distorted way. Why is due to the theory of representing what the value between the different and the points will be.



Bottom Plane of the cylinder



Construction of an Intermediate well

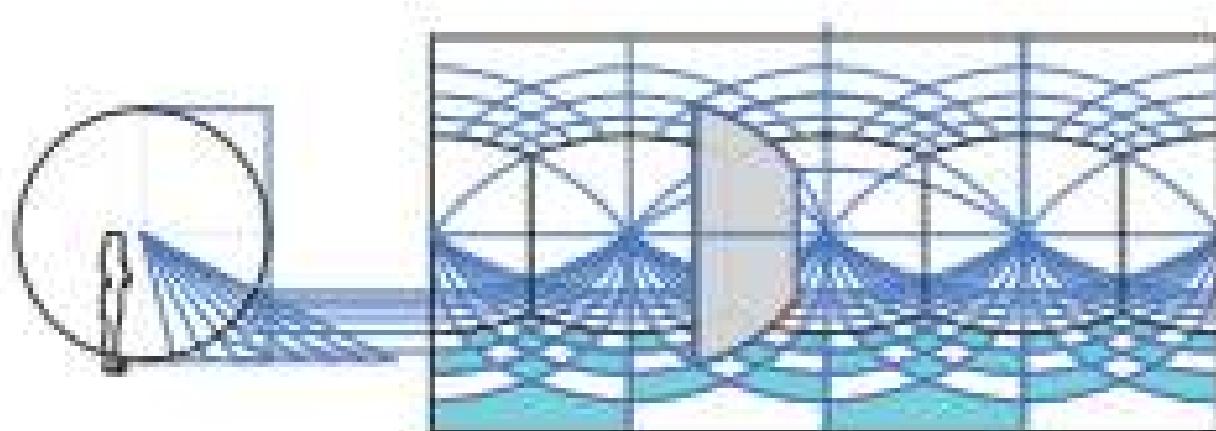
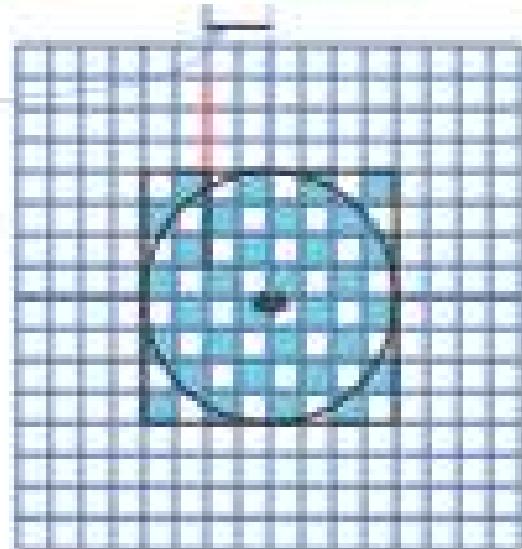
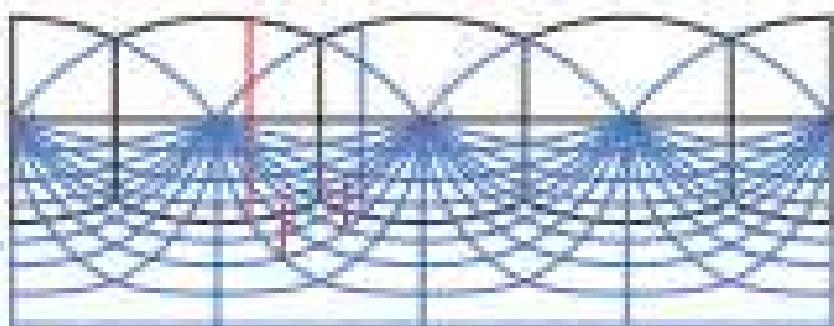
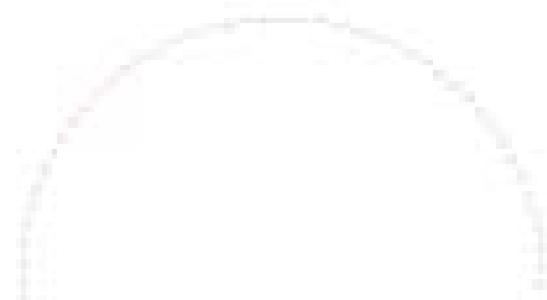


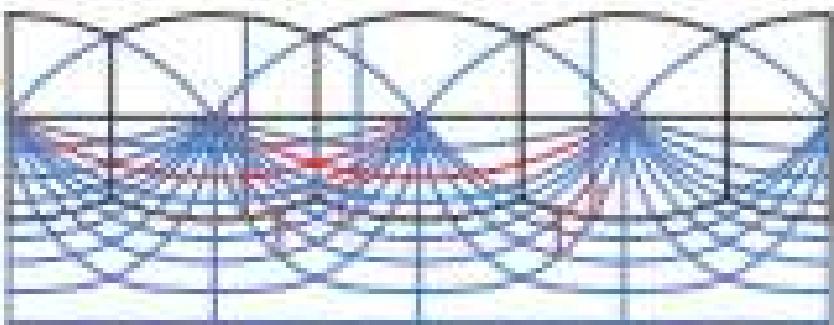
Diagram of the intermediate well
from the controller.



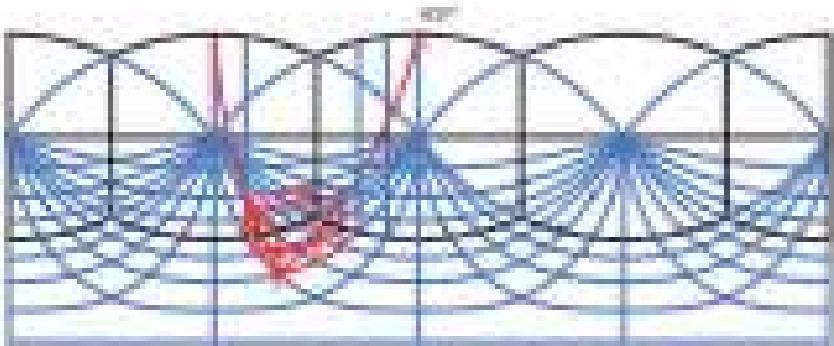
Construction of a Cube



1st curve = Diagonals



2nd curve = Diagonals



3rd curve = Diagonals



The original shape of the cube is outlined.

Increase construction of the quadrilateral properties



Projection from a spherical surface onto a rectangular surface, tangent to the sphere.

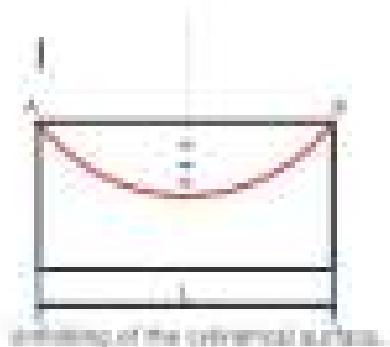


Diagram of the spherical surface.

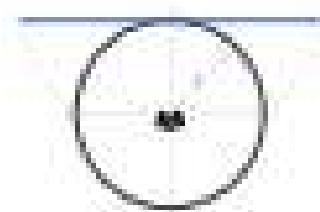


Vertical curves from the sphere.



The horizontal angle is less important because the intersection with the spherical surface will always be correctly defined.

Top and bottom of a set?



$1.00 = \text{Sphere} + 0.00 \text{ length}$

The spherical radius
and circumference angle is relative to the point. In this case 360° corresponds to 1.00 L.

3 Copy and move the lower curve from 0.00 to 0.00



Vertical lines drawn at the intersection with the points determined by the closed curve.

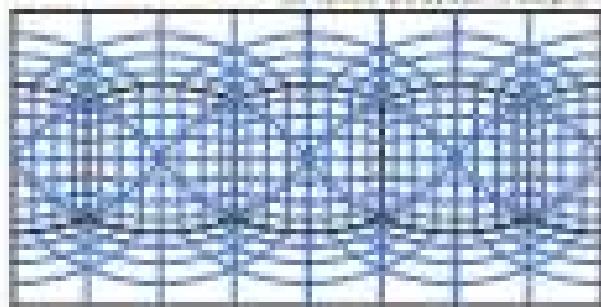
4 Drawing smooth curves through all of points



5 Continue drawing curves through points



6 Complete projection diagram



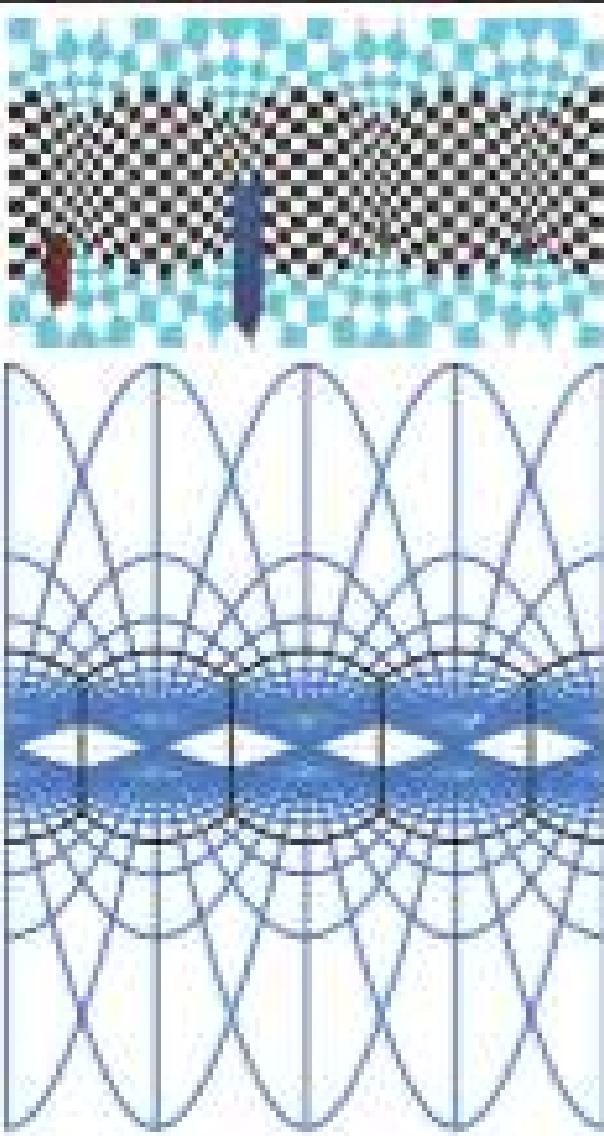
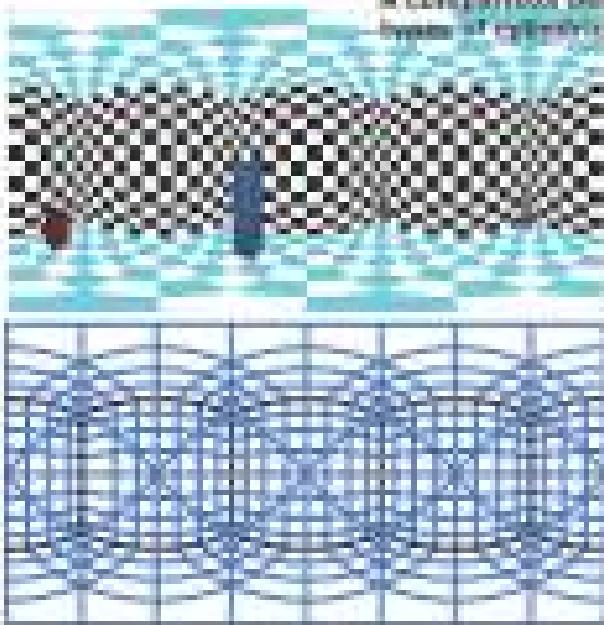
Equidistant cylindrical projection



Simple conical projection

BT

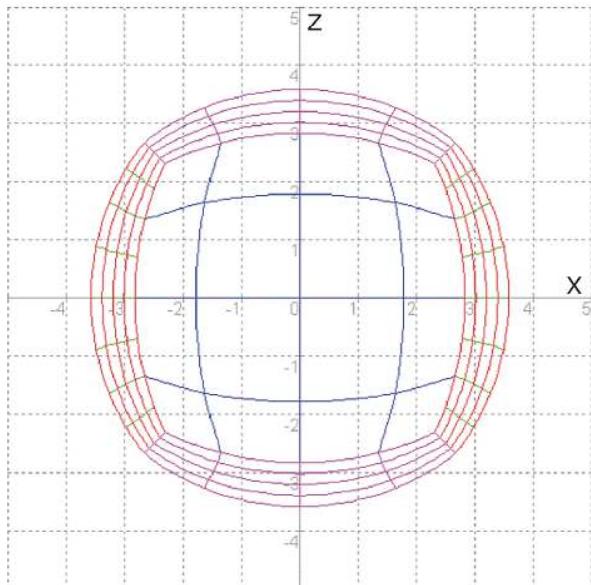
A comparison between two types of cylindrical projections



Chapter 2

Mathematical equations

The mathematical equations convert 3D coordinate (x,y,z) to 2D (x1,z1) coordinate.



Plotted with DecimalBASIC

Many thanks to Marco Masetti for the perspective formulas

PDF

<https://marcomasettiprospettico.wordpress.com/2014/04/16/la-prospettiva-e-la-costruzione-dello-spazio-figurativo/>

E-book

<https://www.ibs.it/prospettiva-costruzione-dello-spazio-figurativo-ebook-marco-masetti/e/9788891154750>

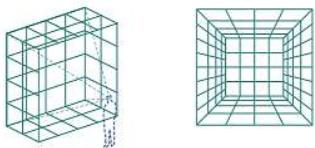
Paper book

<https://www.youcanprint.it/youcanprint-libreria/manualistica/la-prospettiva-e-la-costruzione-dello-spazio-figurativo-9788891130709.html>

<https://www.amazon.it/prospettiva-costruzione-dello-spazio-figurativo/dp/8891130702>

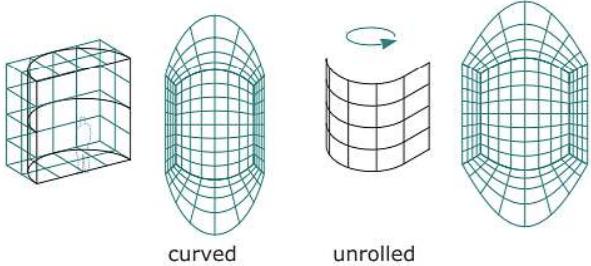
Linear Perspective

(One-Two-Three-point perspective)



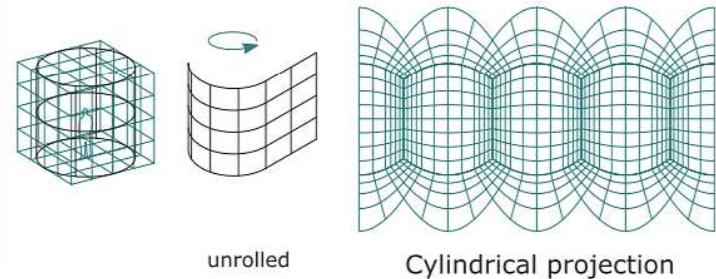
Cylindrical Perspective

(Two-point perspective)



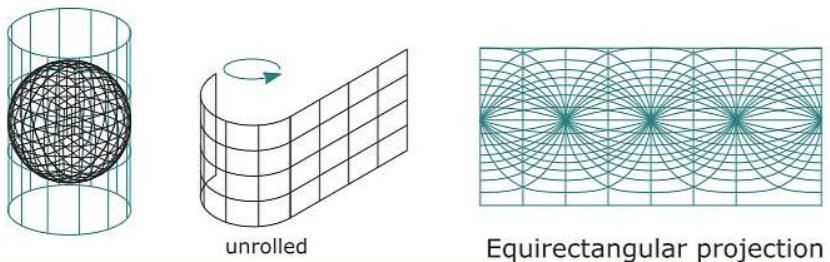
Cylindrical Perspective

(Four-point perspective)



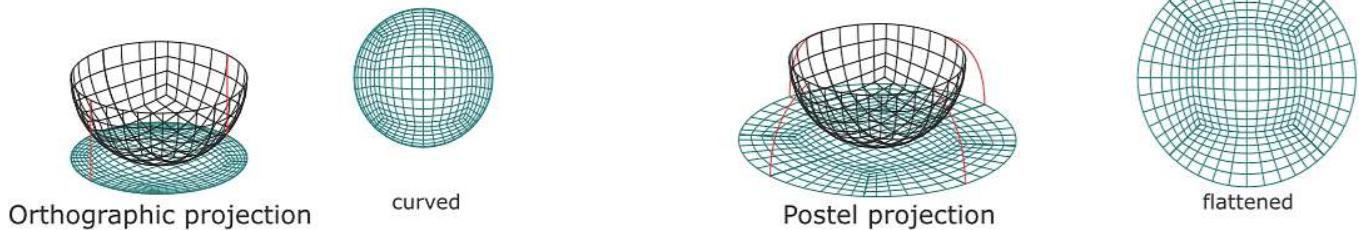
Cylindrical Perspective

(Six-point perspective)



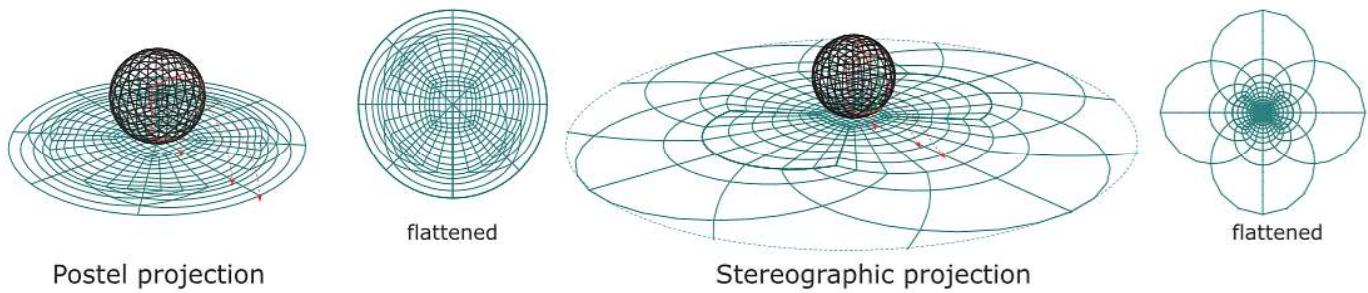
Hemispherical Perspective

(Five-point perspective)



Spherical Perspective

(Six-point perspective)



Legend for the perspective diagrams

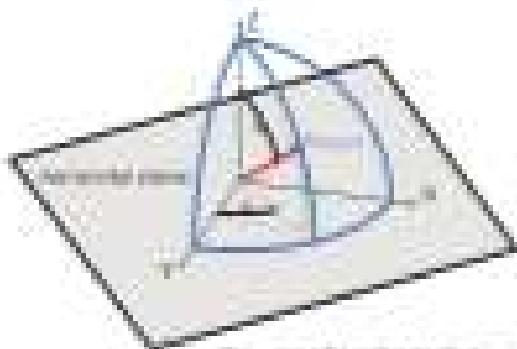
Mathematical functions for programming

abs(x) = the absolute of x
atan2(x,y) = atan(y/x)
 $\pi \approx 3.14159$
sgn(x) = sign of x
 $\sqrt{x} = \text{sqrt root of } x$

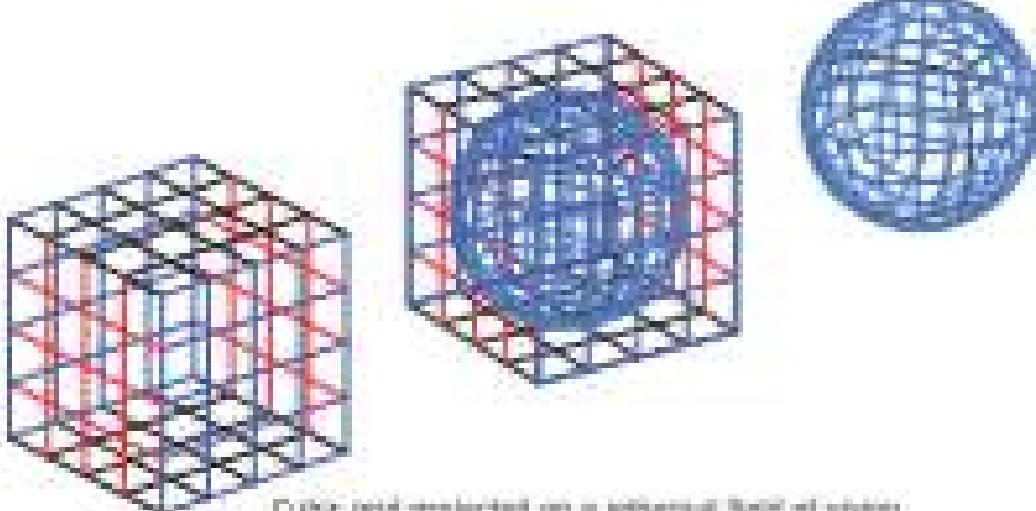
(x,y) = coordinates don't make atan2(y/x) an angle (x,y)



Common coordinate system



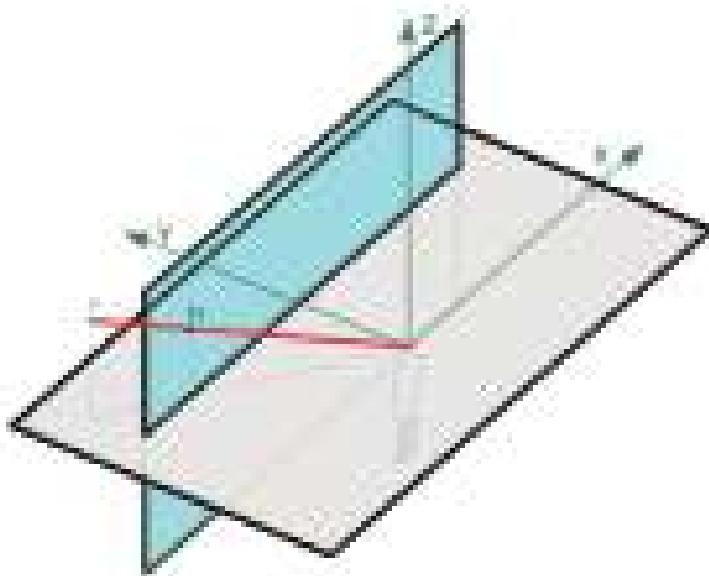
Spherical Coordinate System



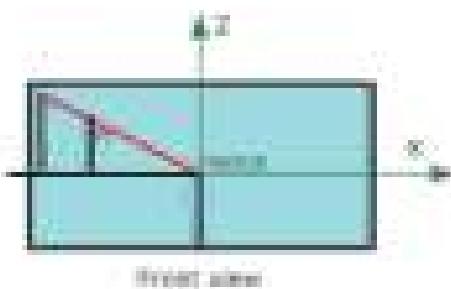
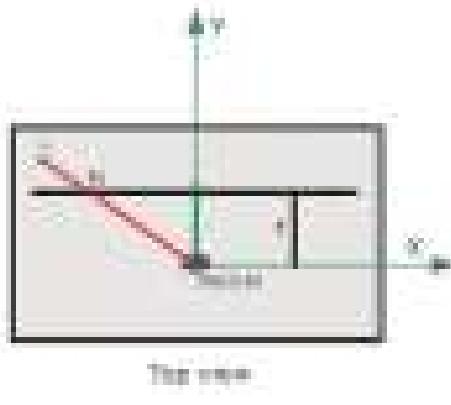
Cubic grid projected onto spherical field of view

Drawing perspective by mathematical equations

The picture plane
 $P = (x_1, y_1, z_1)$
 The 3D position of P in the Picture Plane



Linear View
 1 vanishing point

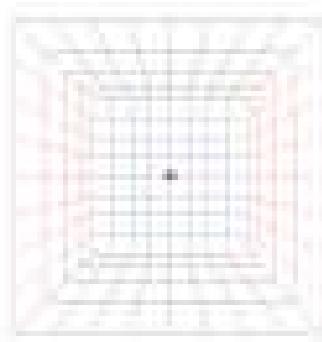


Math Formulas

Linear perspective

- x_1, y_1, z_1 = coordinates of point P
- x_1, y_1, z_1 = transformed coordinates of point P
- $x_1 = t^{-1} \cdot x_0$
- $y_1 = t^{-1} \cdot y_0$
- $z_1 = t^{-1} \cdot p \cdot y$

1-vanishing point



Browsing perspectives by mathematical equations

W = planar plane

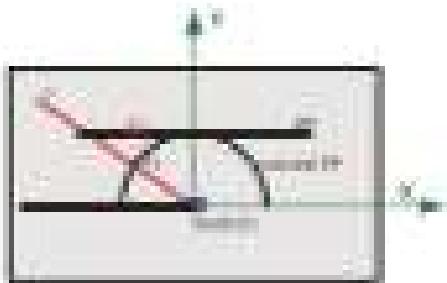
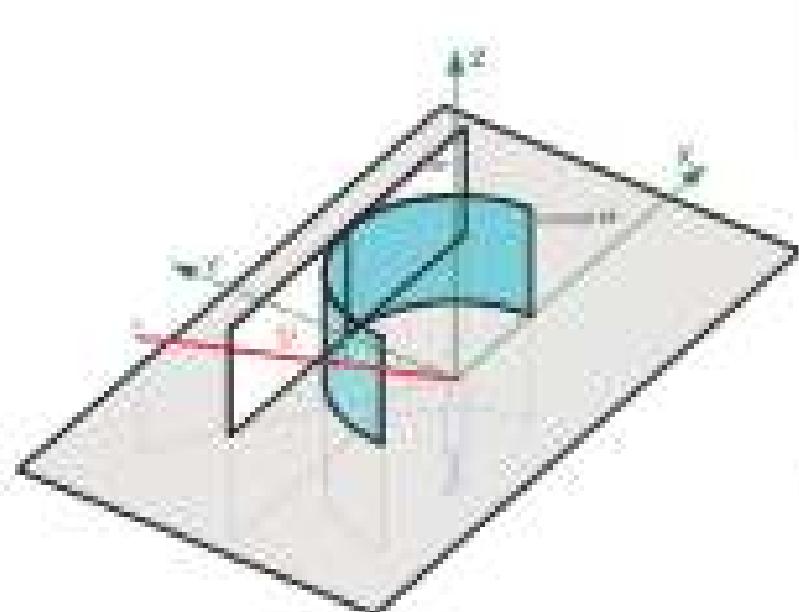
P = point

The image is projected on W via the curved Polar View:

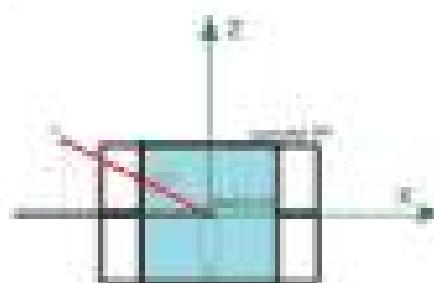
(θ, ϕ, ψ) = rotation angles

Curved Cylindrical View

3-watching point



Top view



Front view

Math formulas

3-watching point

Cylindrical perspective (curved)

center of the volume

$$M = M^{\text{3D}}$$

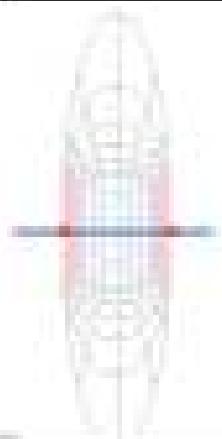
(x_0, y_0, z_0) coordinates of point P

$(\theta_0, \phi_0, \psi_0)$ transformation coordinates of point P

$$r_0 = r^{\text{3D}}$$

$$\phi_0 = \phi^{\text{3D}}$$

$$\theta_0 = \theta^{\text{3D}}$$



Curved polar view

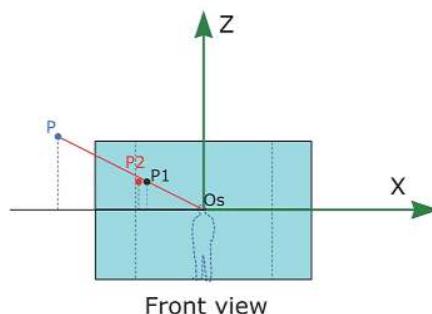
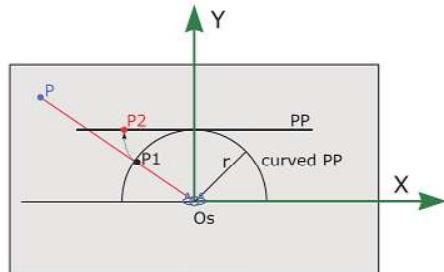
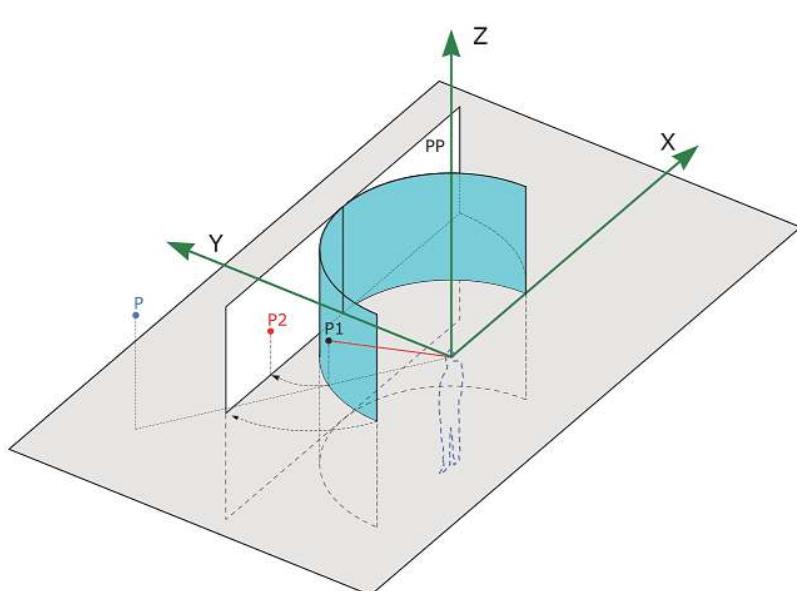
Drawing perspective by mathematical equations

PP= picture plane

 $P = (x, y, z)$ point $P_1 = (x_1, y_1, z_1)$ projection of P on the curved Picture Plane $P_2 = (x_2, y_2, z_2)$ Projection of P_1 on the PP

Unrolled Cylindrical View

2-vanishing point



Math formulas

Cylindrical perspective (unrolled)

 $r = \text{radius of the cylinder}$

$$ro = \sqrt{x^2 + y^2}$$

$$\alpha_l = \arccos(y/ro)$$

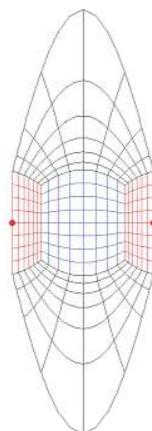
 $x, y, z = \text{coordinates of point } P$ $x_2, y_2, z_2 = \text{transformed coordinates of point } P$

$$x_2 = \text{sgn}(x) * r * \alpha_l * \pi / 180$$

$$y_2 = r$$

$$z_2 = r * z / ro$$

2-vanishing point

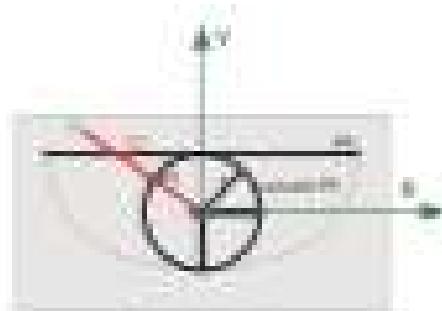
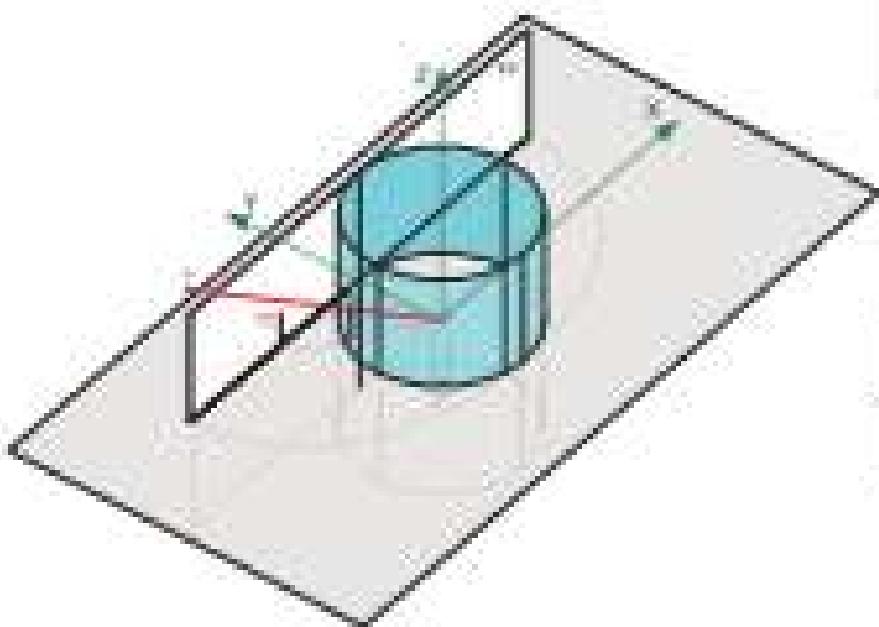


Cylindrical projection

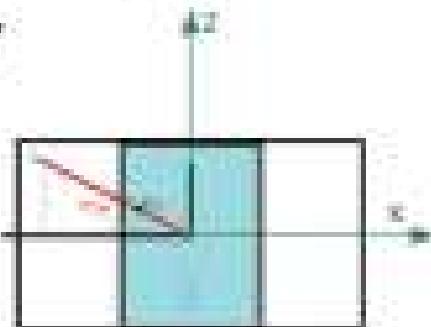
Drawing perspectives by mathematical equations

Orthographic plan:
 $\pi = \text{constant}$
 Plan (constant distance of π from the cylinder's Polymer Plane)
 Plan (constant angle of θ to the axis)

Unrolled Cylindrical View
 4-viewing point



Front view



Top view

Math formulas

4-viewing point

Cylindrical perspective

$r = \text{radius of the cylinder}$

$$r\theta = \sqrt{x^2 + y^2}$$

$\theta = \text{angle of point P}$

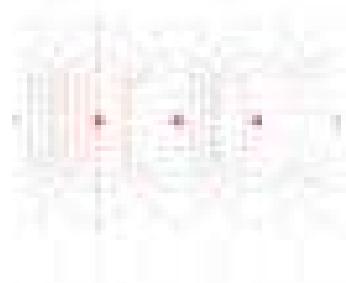
$x, y, z = \text{coordinates of point P}$

$x_0, y_0, z_0 = \text{transformed coordinates of point P}$

$$x_0 = r\cos(\theta) \cdot \cos(\phi)$$

$$y_0 = r\cos(\theta) \cdot \sin(\phi)$$

$$z_0 = r\sin(\theta)$$



Front view

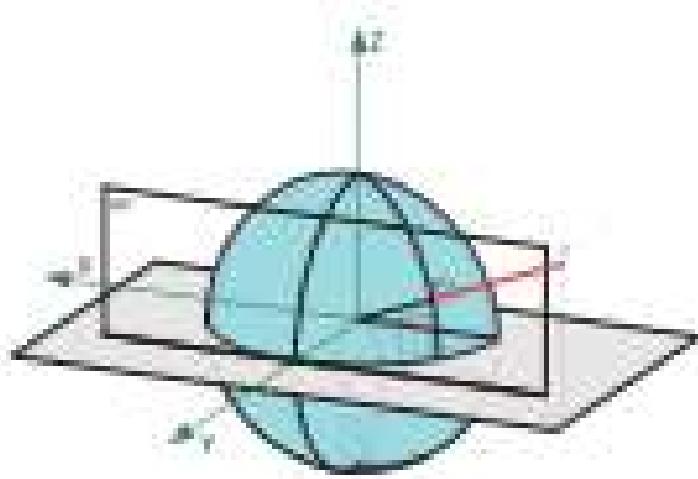
Drawing perspectives by mathematical equations

From picture plane:

$$P' = \text{Project}(P)$$

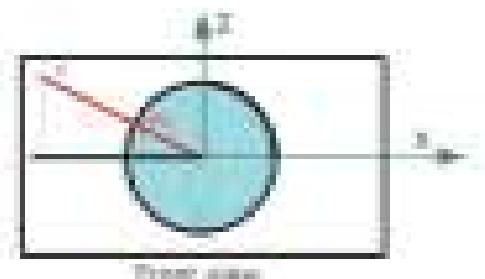
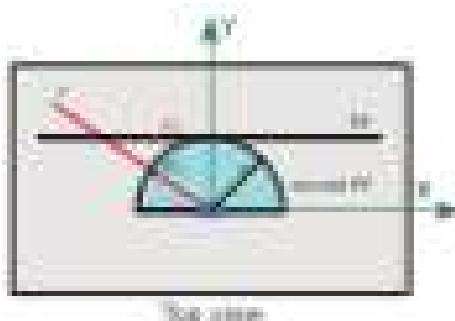
P' is always a perspective of P on the Mathematical Picture Plane.

P' is the coordinates of P with basis B' .



Curved Hemispherical View

Screening point



Math formulas

Screening point

Spherical perspective (curved)

Radius of the sphere

$$R = \sqrt{R_x^2 + R_y^2}$$

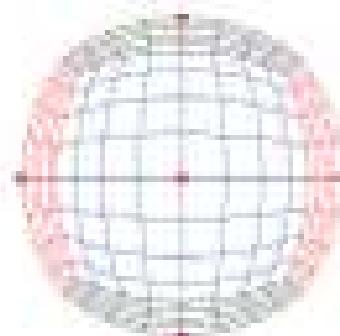
x, y, z coordinates of point P

x_0, y_0, z_0 transformed coordinates of point P

$$R_x = r^{-1} \text{ km}$$

$$y_0 = R_x \cdot y$$

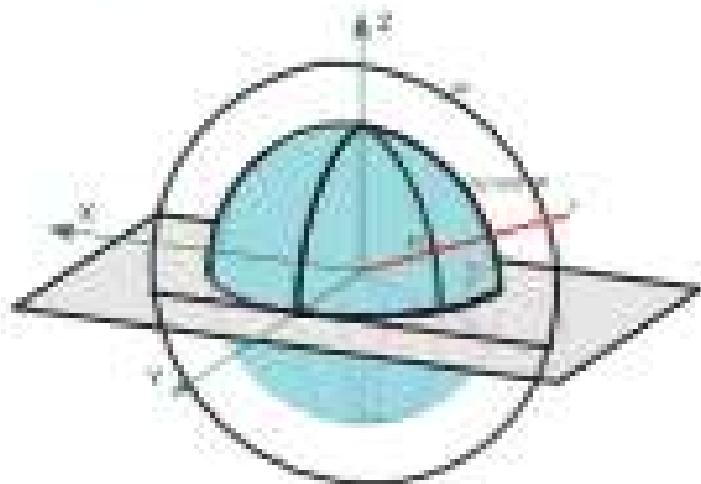
$$z_0 = R_x \cdot z$$



Orthographic projection

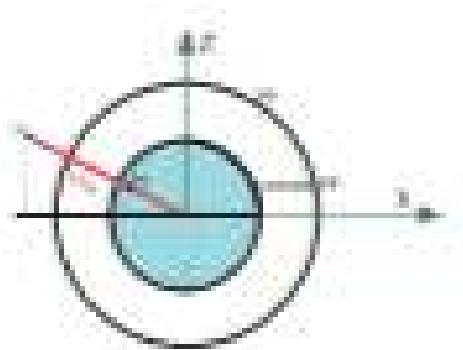
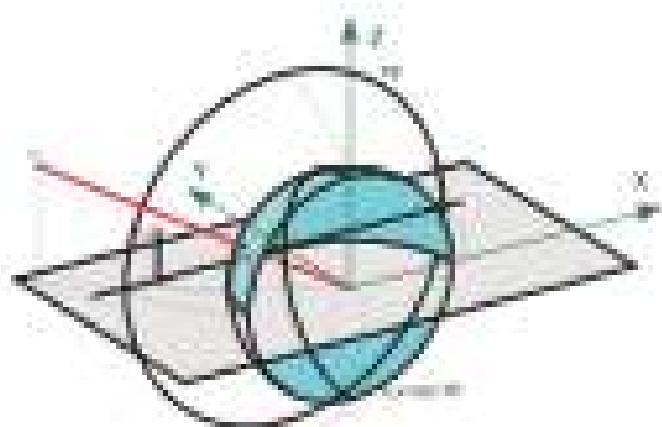
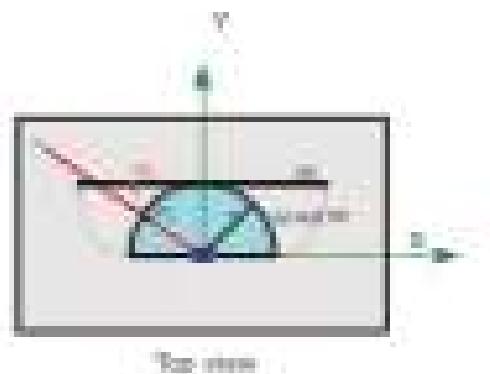
Drawing perspective by mathematical equations

The surface plane:

 $P = \text{Plane}(R)$ P is the intersection of P and the horizontal Project PlaneP is the result of transformation of P and R 

Flattened View (Spherical View)

3-viewing point



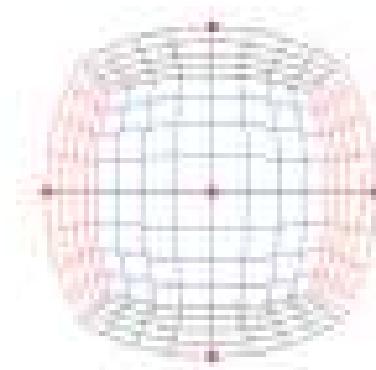
Front view

3-viewing-point

Spherical perspective (flattened):

 $r = \text{radius of the sphere}$ $r = \sqrt{x^2 + y^2 + z^2}$ $\alpha = \text{azimuthal angle}$ $\beta = \text{elevation angle}$

i.e. coordinates of point P

 $(x_1, y_1, z_1) = \text{transformed coordinates of point } P$ $x_1 = r \cos(\beta) \cos(\alpha)$ $y_1 = r \sin(\beta)$ $z_1 = r \cos(\beta) \sin(\alpha)$ 

Front projection

Drawing perspective by mathematical equations

Other useful terms:

$\theta = \text{azimuth}$

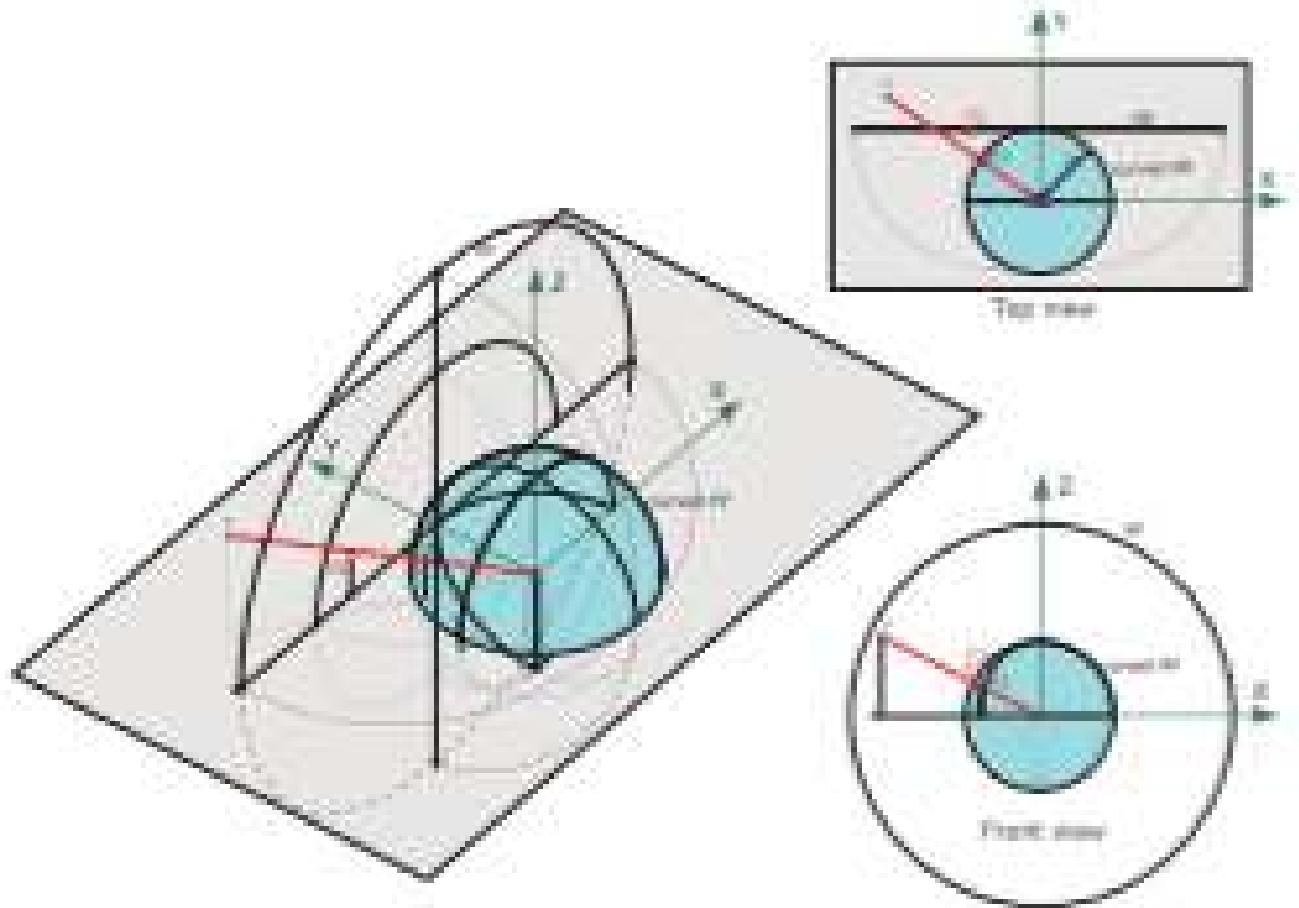
$\phi = \text{elevation}$ projection of P onto the Horizontal Project Plane

$\psi = \text{roll}$ rotation around the X-axis, θ'

$\alpha = \text{pitch}$ rotation around the Y-axis, ϕ'

Flattened Spherical View

6-vanishing point



Plane Equation:

Spherical perspective
(flattened 6-vanishing point)

$r_0 = \text{radius of the sphere}$

$$r_0 = \sqrt{x^2 + y^2 + z^2}$$

$\phi_0 = \text{azimuth}$ $\theta_0 = \text{elevation}$

$$\theta_0 = \arctan\left(\frac{y}{x}\right) \quad \phi_0 = \arccos\left(\frac{z}{r_0}\right)$$

$x_0, y_0, z_0 = \text{coordinates of point } P$

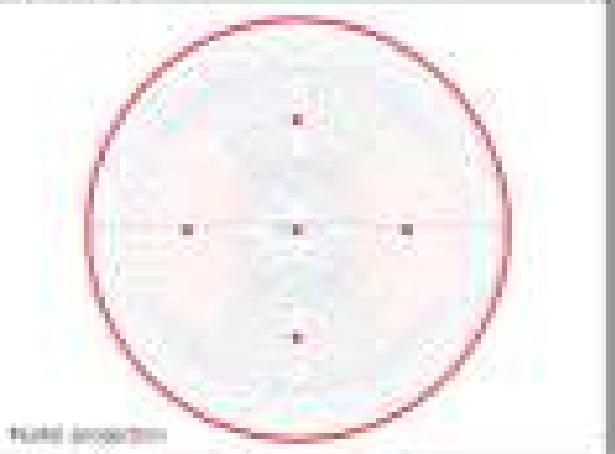
$x_0', y_0', z_0' = \text{transformed coordinates of point } P'$

$$x_0' = r_0 \sin \theta_0 \cos \phi_0 \quad (\text{horizontal position})$$

$$y_0' = r_0 \sin \theta_0 \sin \phi_0$$

$$z_0' = r_0 \cos \theta_0 \quad (\text{depth position})$$

6-vanishing point



Drawing perspective by mathematical equations

The picture shows:

P' is a point

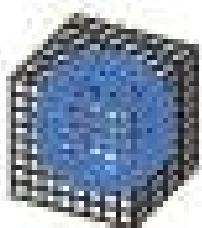
P' is a perspective of P on the Spherical Picture Plane

P' is a perspective of P on the spherical tangent to the sphere

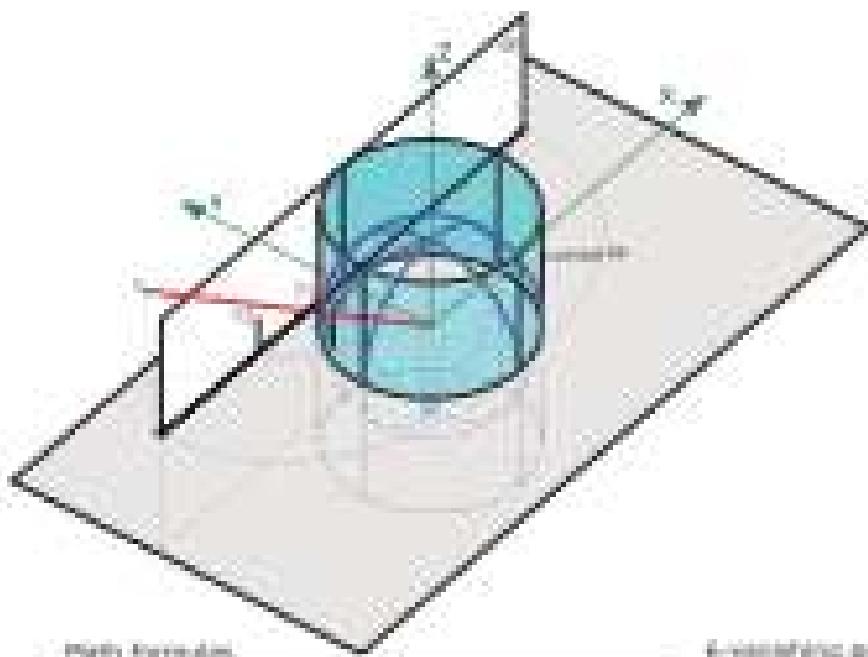
P' is a perspective of P on the Extended Picture Plane

Flattened Spherical View

Flattening point

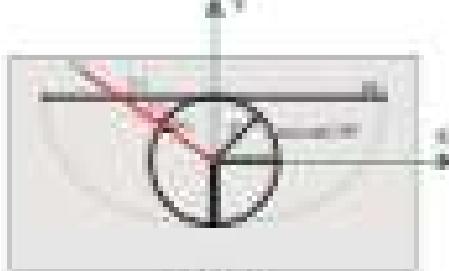


Cubic environment (in clockwise) a spherical view of sphere and subsequent flattening on the ground.

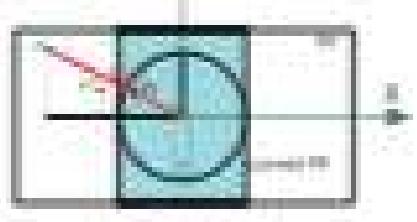


Plane formulae:

Flattening point:



Top view



Front view

Cylindrical perspective

The radius of the sphere:

$$r = \sqrt{x^2 + y^2}$$

2D cylindrical coordinates of a point P :

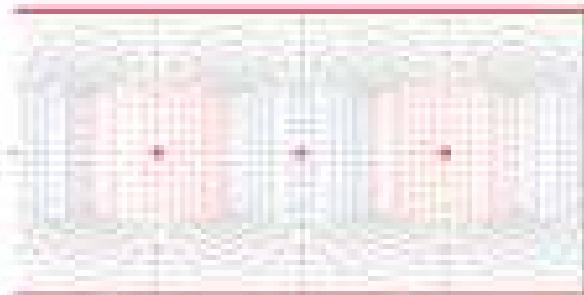
$p_1 = \text{horizontal distance from vertical axis}$
 $p_2 = \text{vertical distance from horizontal axis}$

2D coordinates of point P :

(p_1, p_2) = transformed coordinates of point P

$$x_2 = (p_1 \cdot \cos(p_2))$$

$$y_2 = (p_1 \cdot \sin(p_2))$$



Indirect linear drawing

Drawing perspective by mathematical equations

Def. Picture Plane: $\Pi = \{x_1, x_2, x_3\}$

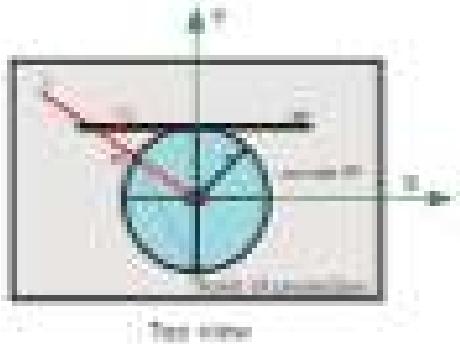
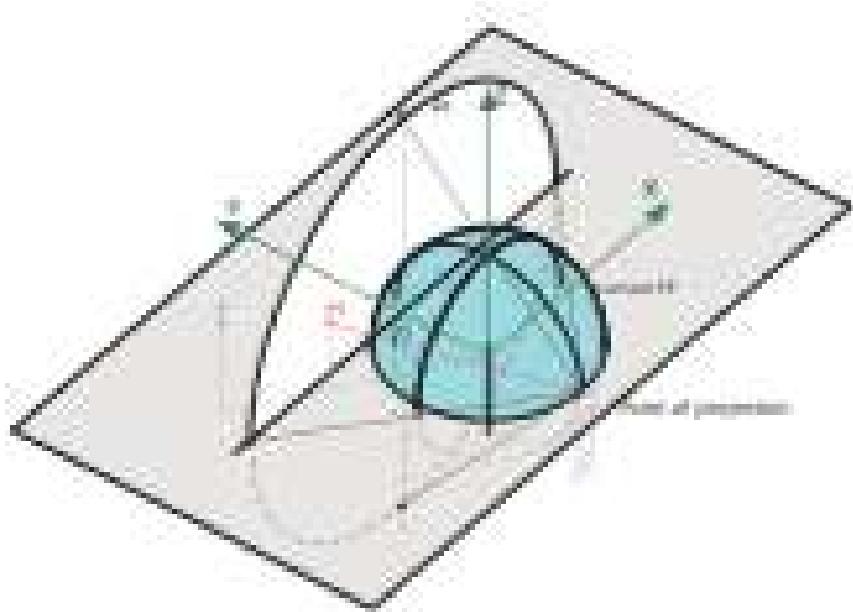
$P = \text{point} \in \text{image of the line } l \text{ in } \Pi$

Def. Picture Perspective of P on the Picture Picture Plane:

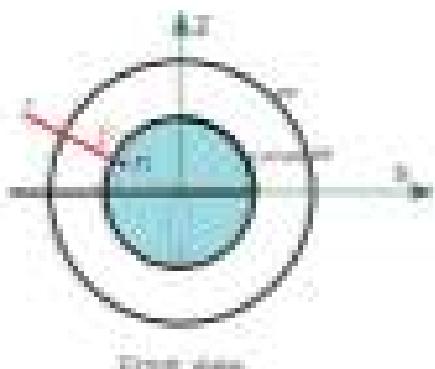
$\Pi_{\Pi} = \text{mathematical projection of every point } P \text{ from the picture plane } \Pi \text{ onto a second plane starting from the fixed } O \text{-projection point}$

Flattened Spherical View:

O=projection point



Front view



Front view

Plane geometry:

O=projection point:

Spherical perspective:

$r = \text{radius of the cylinder}$

$r_0 = \sqrt{x^2 + y^2}$

$\theta_0 = \arccos(\sqrt{r^2 - r_0^2})$

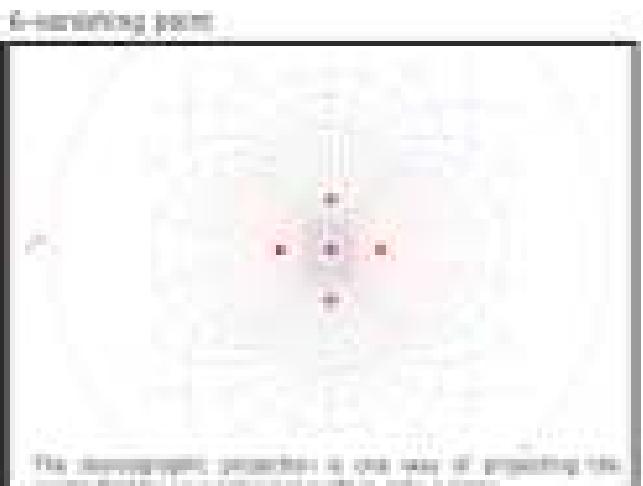
$\pi(x, y) = \text{coordinates of point } P$

$\pi(x_0, y_0) = \text{transformed coordinates of point } P'$

$x_0 = r \cos(\theta_0)$

$y_0 = r \sin(\theta_0)$

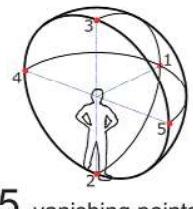
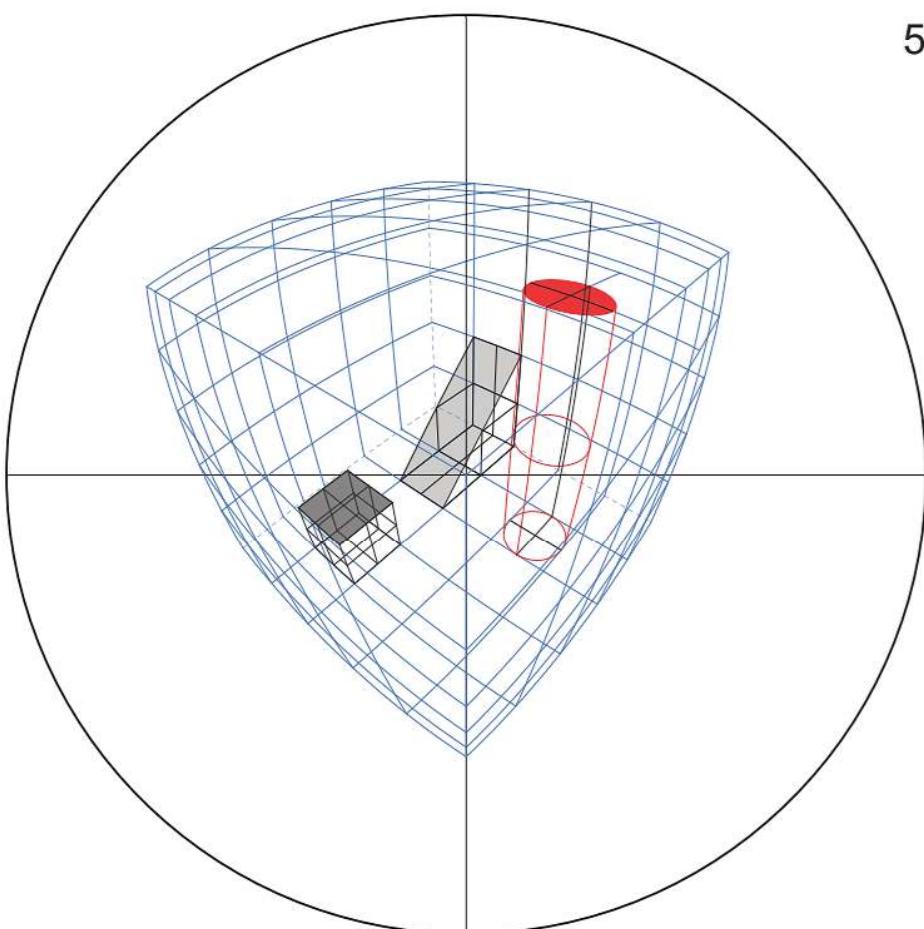
$z_0 = \sqrt{r^2 - r_0^2}$



The flattening perspective is one way of projecting the curved field from a spherical surface onto a plane.

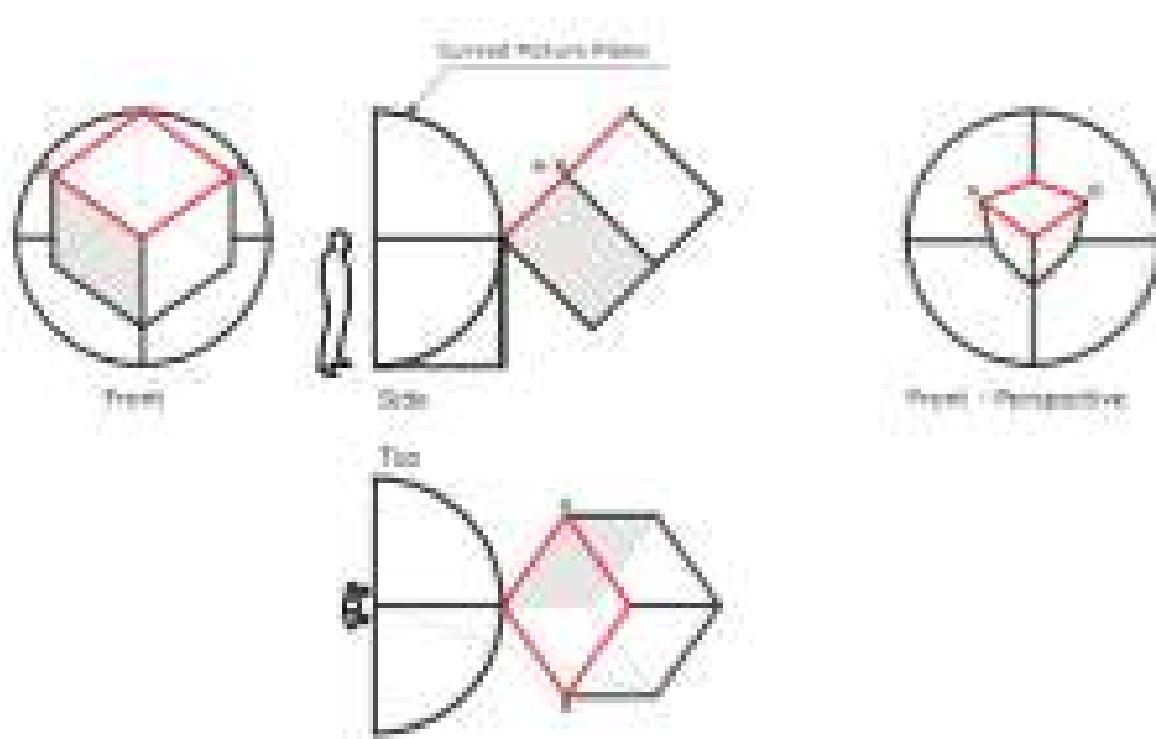
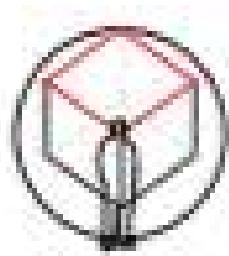
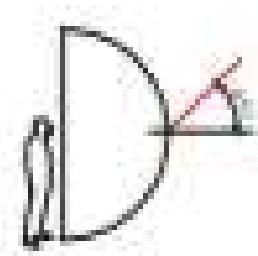
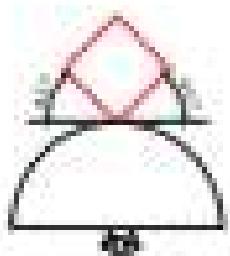
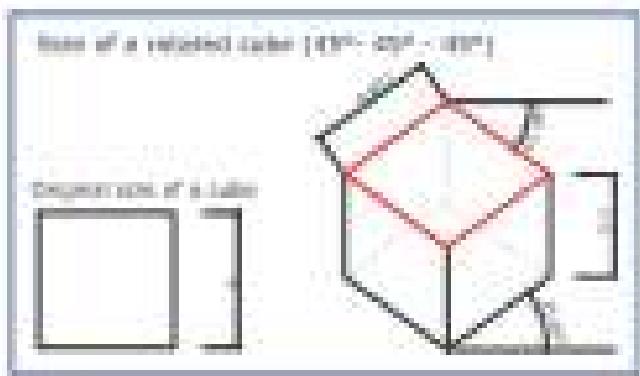
Chapter 3

How to draw a rotated cube in 5-point perspective (angles 45°- 45°- 45°)



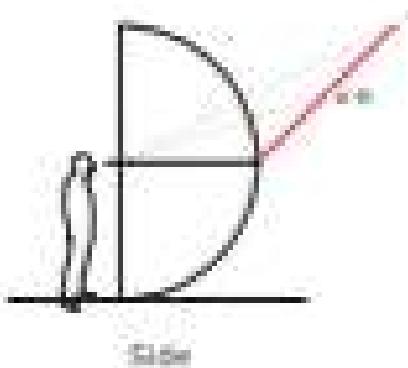
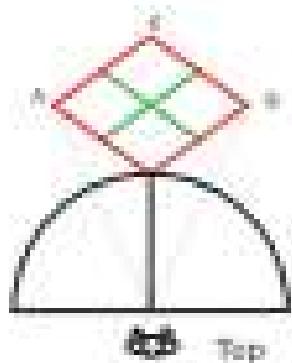
5 vanishing points

3. 3-point perspective of a rotated cube: $45^\circ \times 45^\circ \times 45^\circ$



3, 3-point perspective of
a rotated cube: $45^\circ \times 45^\circ \times 45^\circ$

Upper face



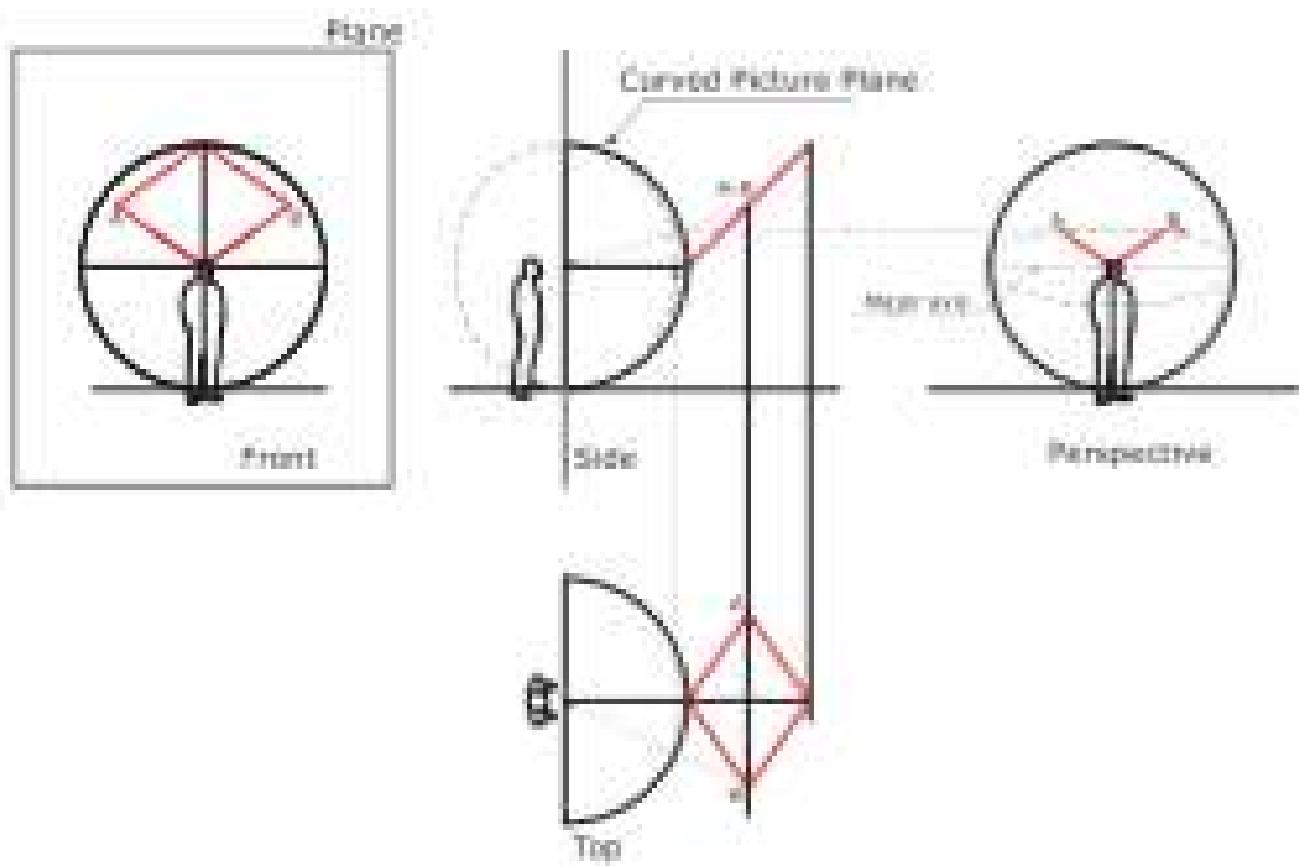
Front - Perspective



3D view

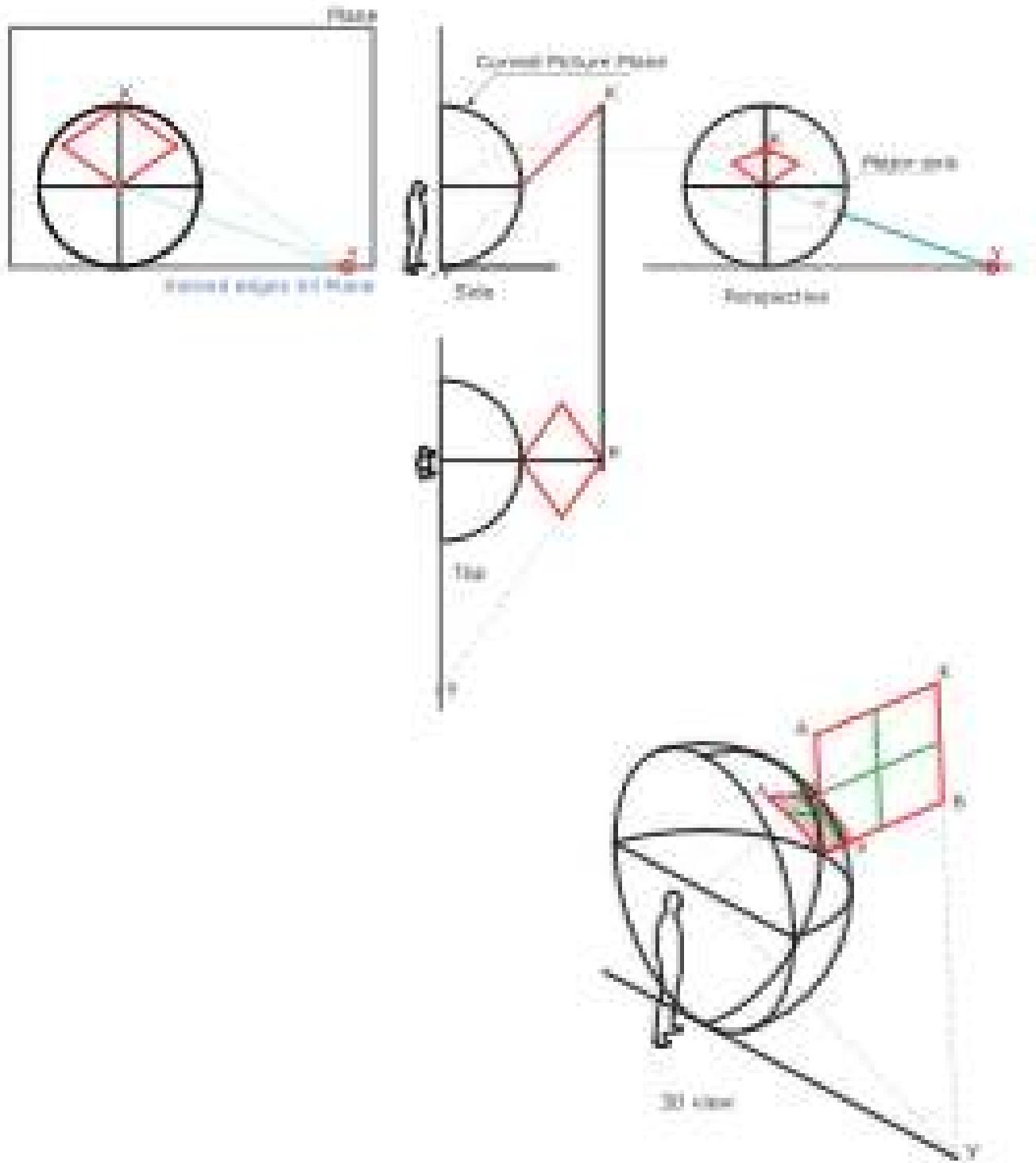
A 3-point perspective of
a rotated circle (30°-45°-30°)

Upper face 1°



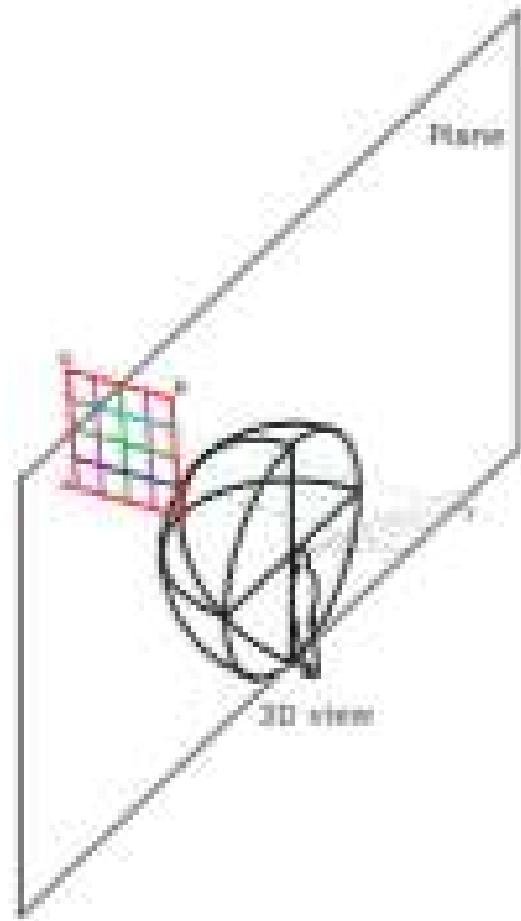
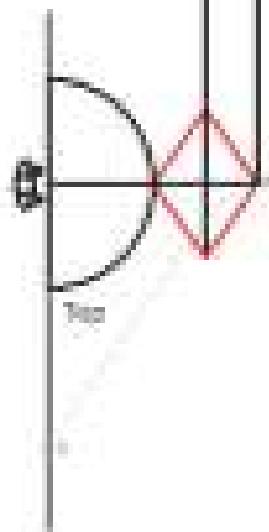
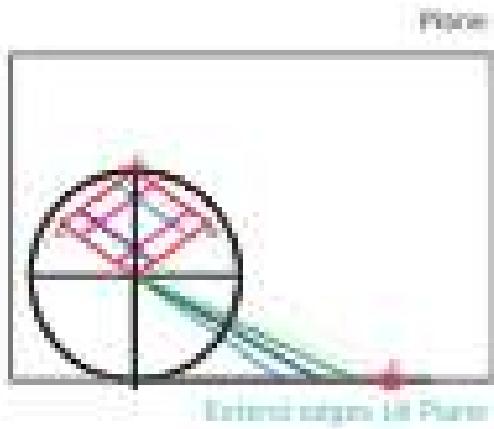
A 3-point perspective of
a rotated cube: $30^\circ \times 45^\circ \times 45^\circ$

Upper face 2°

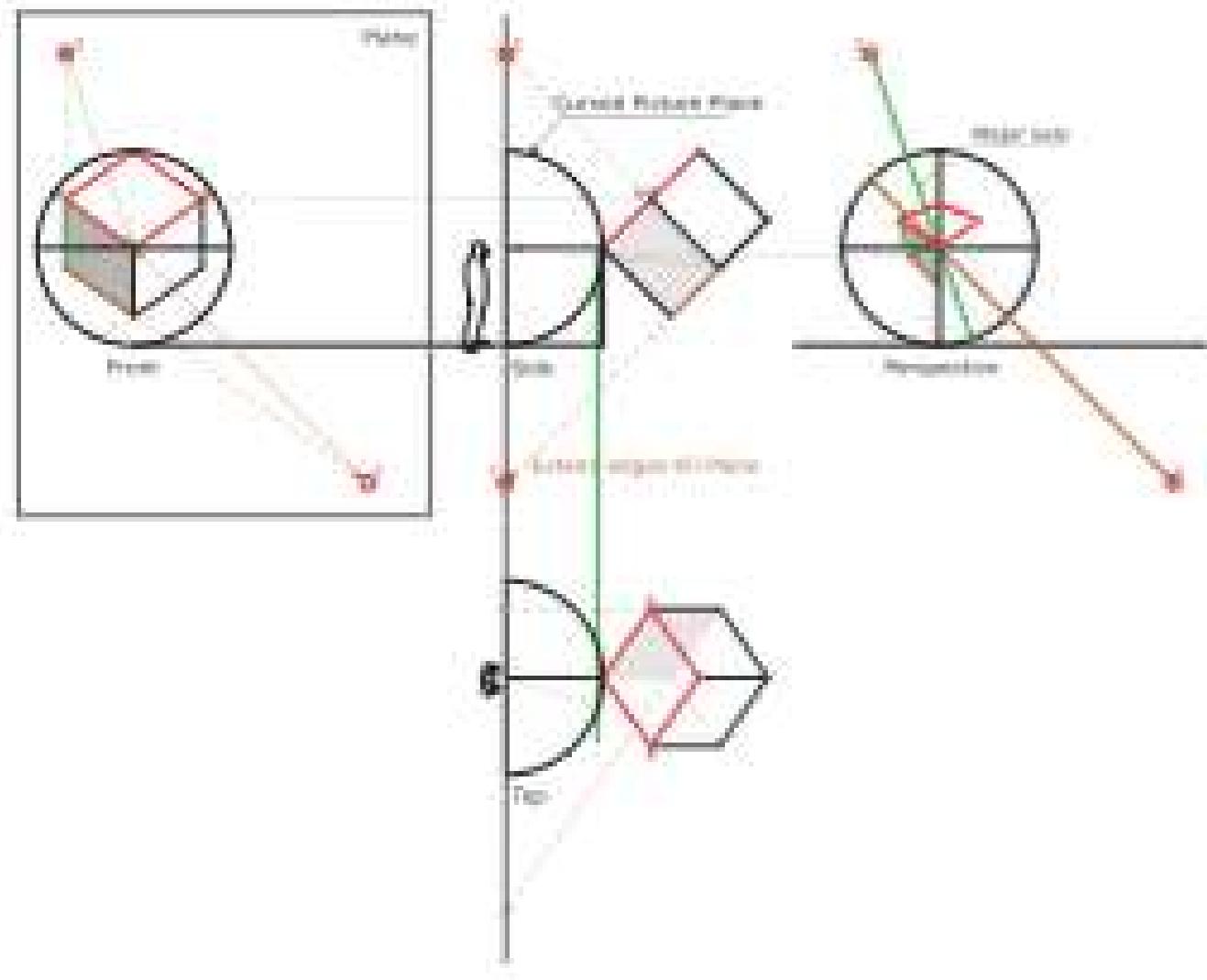


is 3-point perspective of
a rotated cube: $23^\circ - 45^\circ - 45^\circ$

Upper Face



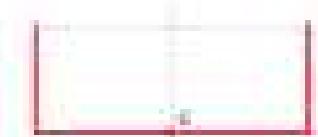
A 3-point perspective of
a rotated cube: $45^\circ \times 45^\circ \times 45^\circ$
Front face



A 3-point perspective of a rotated circle: 23° × 45° × 45°

Drawing ellipses

1



Draw the Major
and Minor axes.

2



Diagonal line

3



Divide in 4 equal sections

4



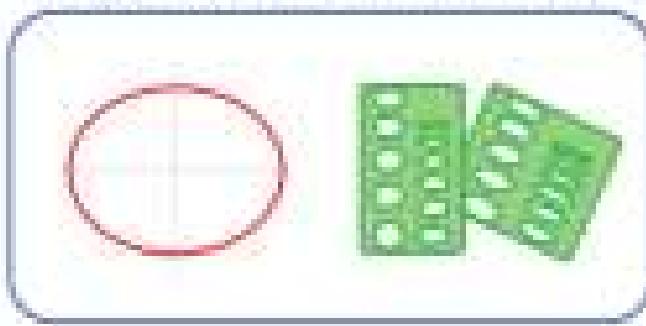
Run diagonal lines
across the sections

5



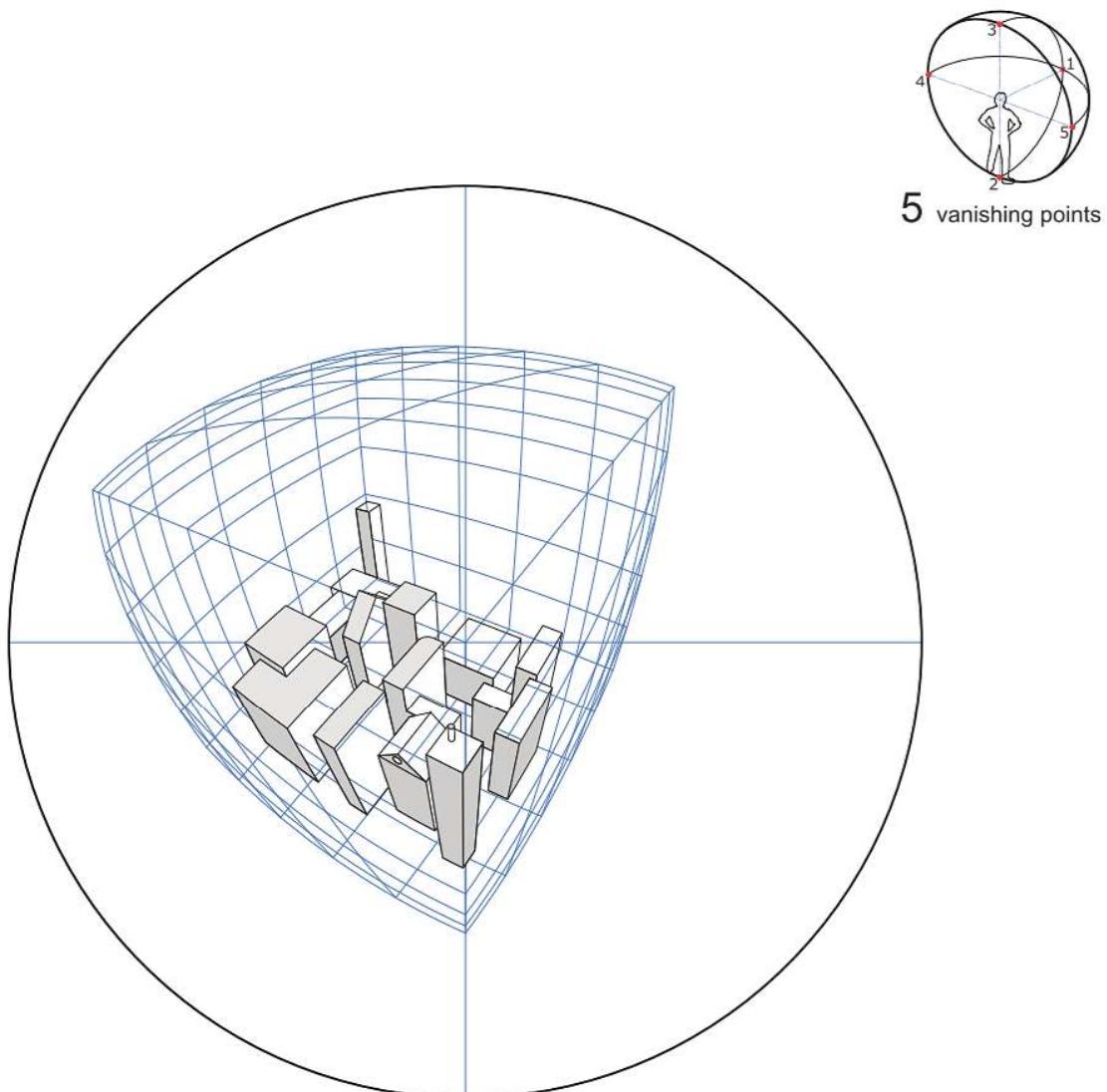
Draw a smooth curve through
the 5 points

For an alternative to pencil and compass, it is even possible to use photo-manipulation:

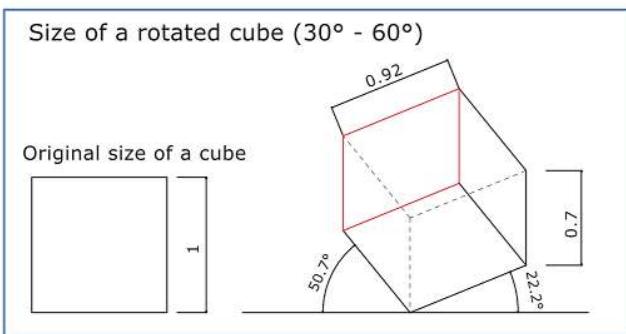


Chapter 4

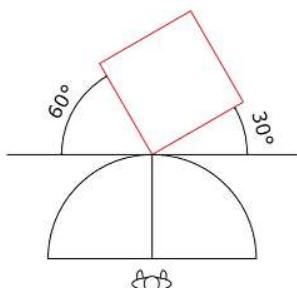
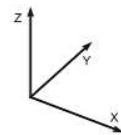
How to draw a rotated cube in 5-point perspective (angles 30°-60° & 15°-75°)



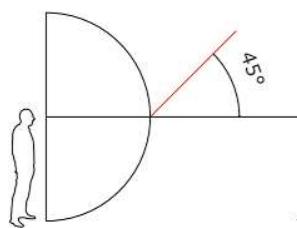
**A 5-point perspective of
a rotated cube: 30°-60°**



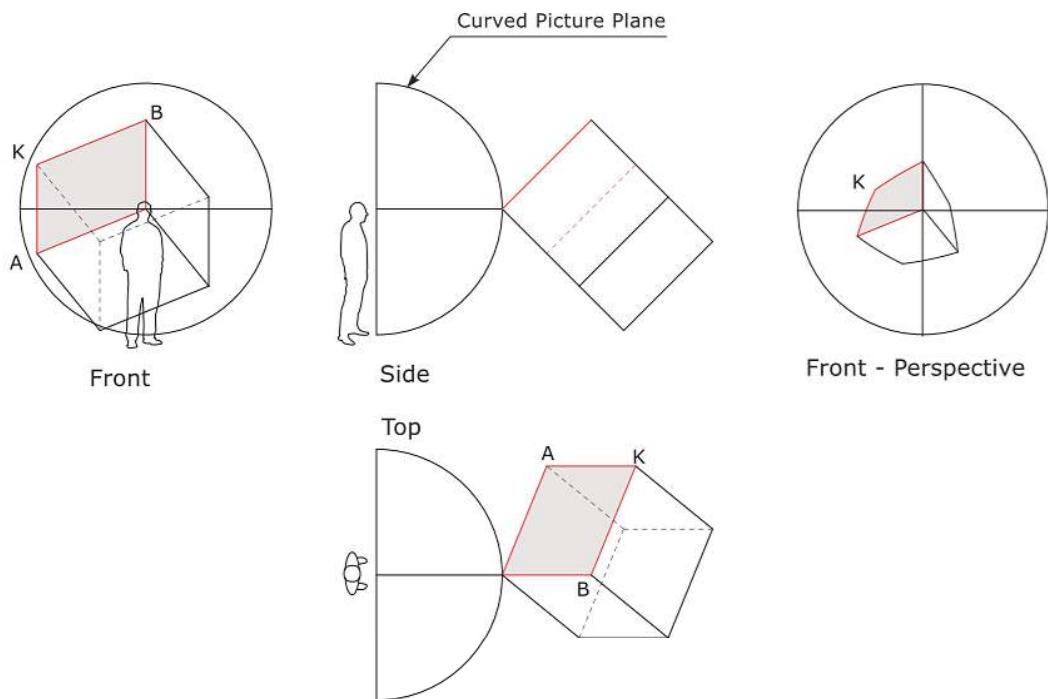
Rotating a cube in three dimensions



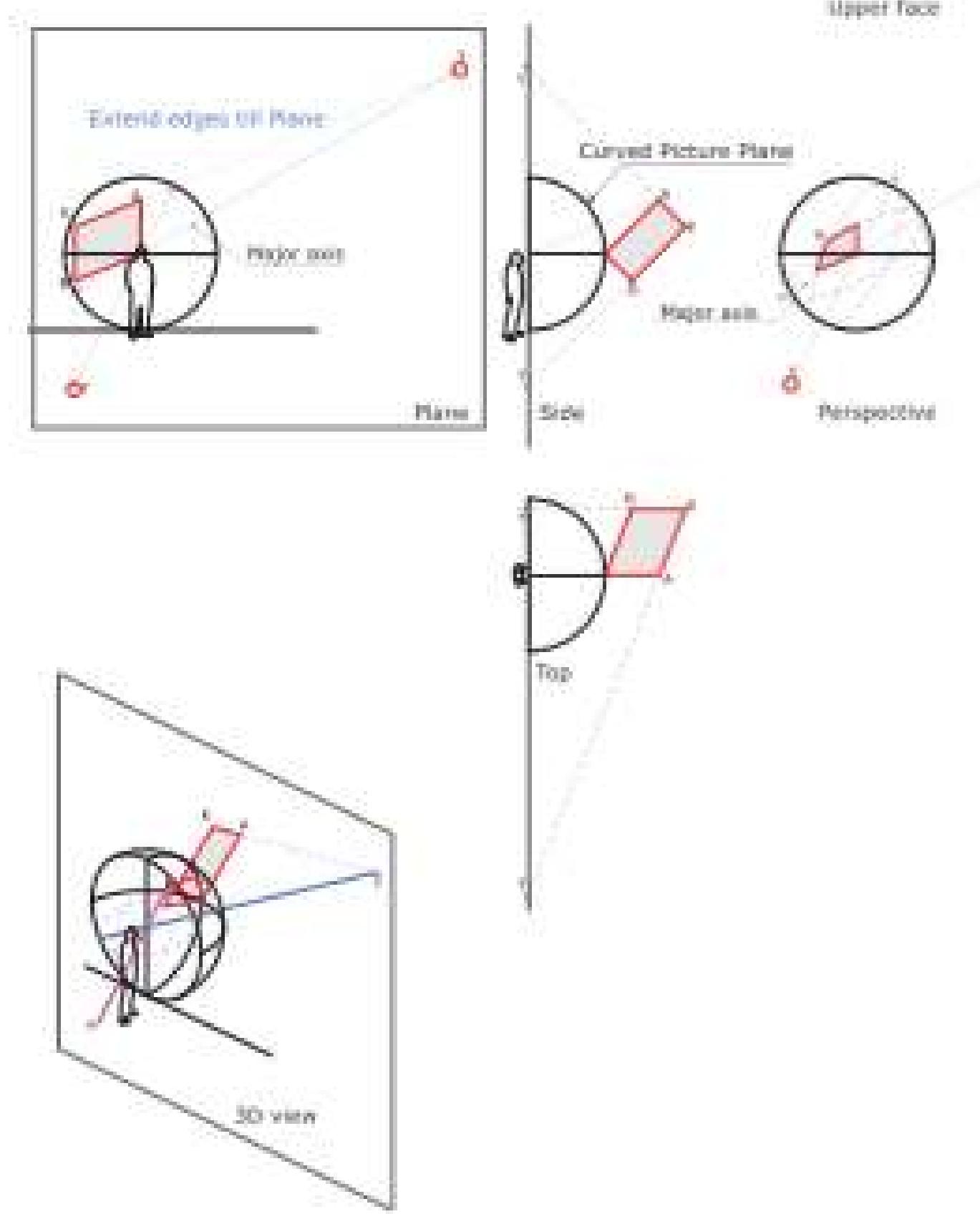
Rotation around the Z-axis by 45°



Rotation around the X-axis by 45°

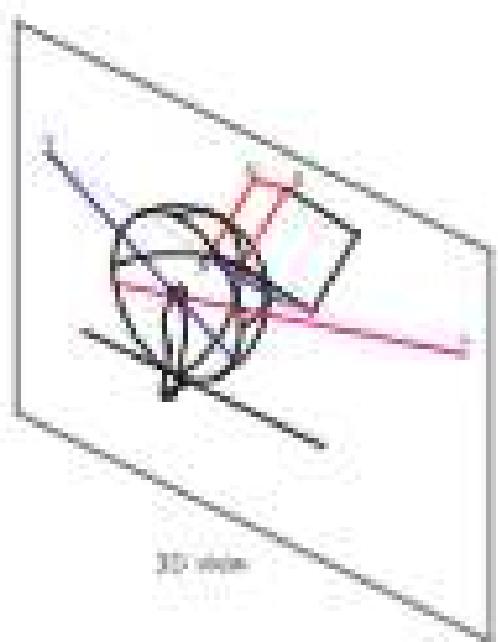
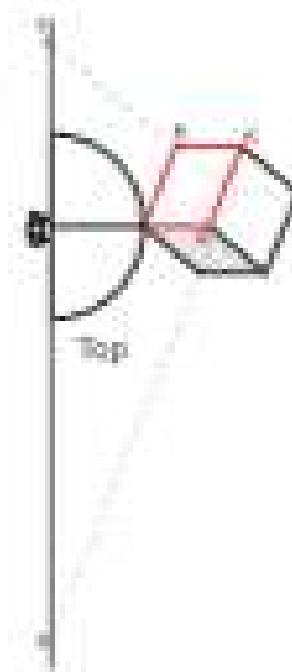
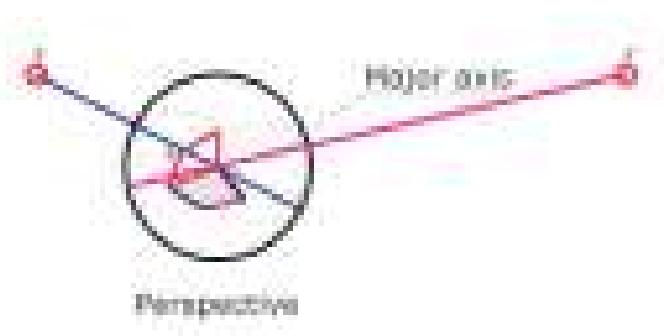
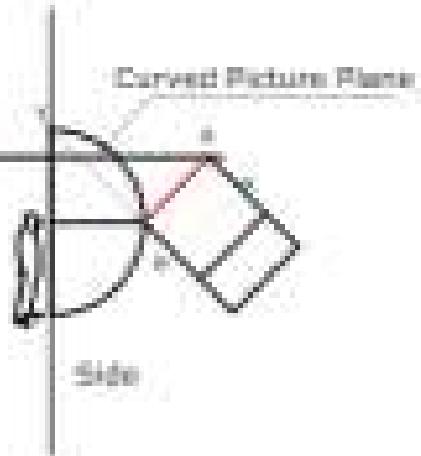
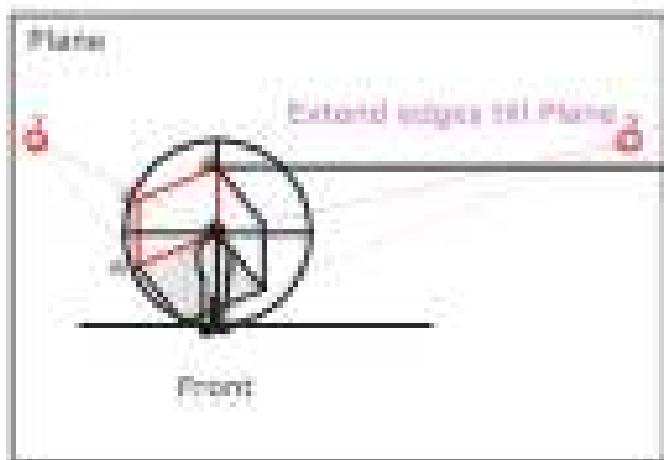


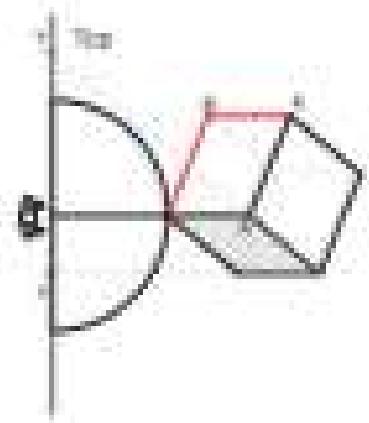
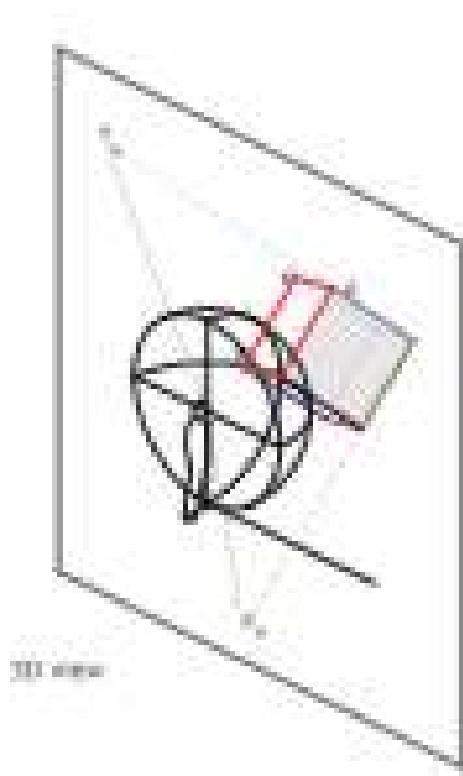
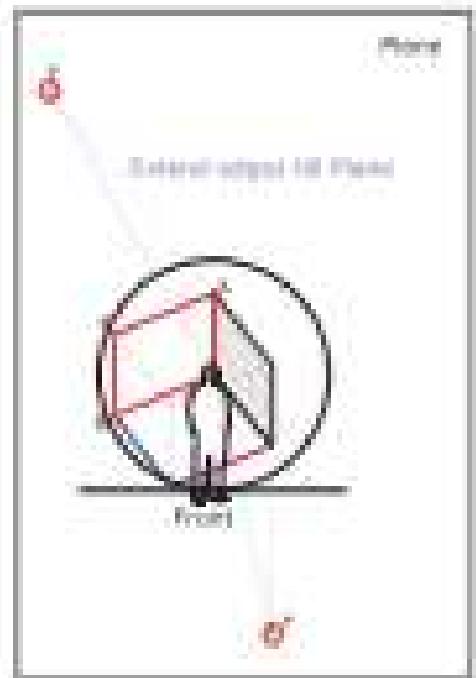
6. 9-point perspective of a twisted surface (30° - 60°)



8. Support perspective of a rotated cube: 3D → 2D

Front face

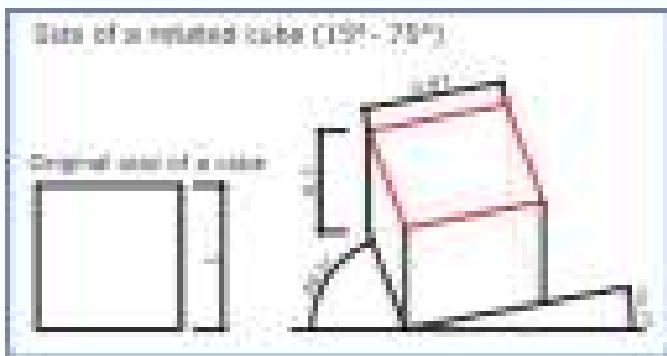




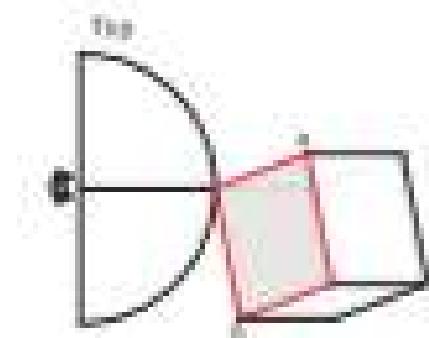
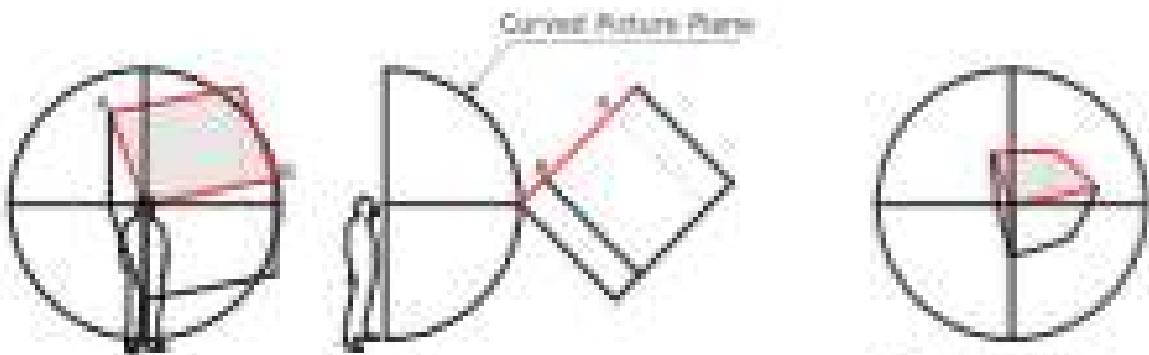
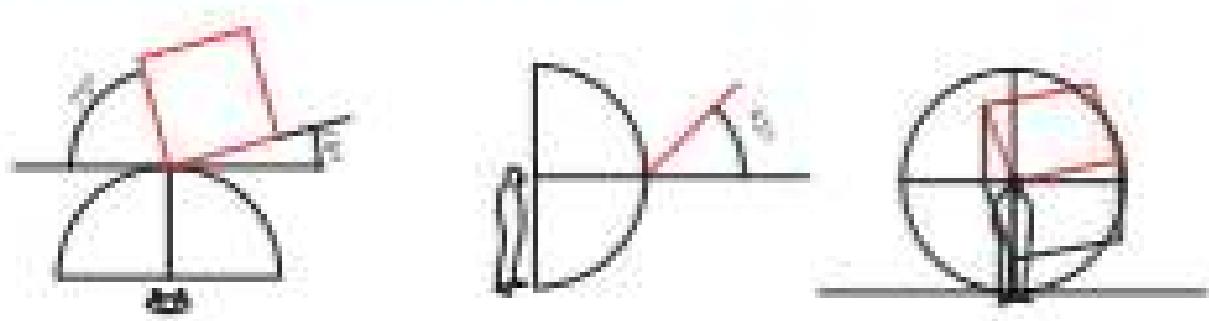
3. 3-point perspective of a rotated cube (35°-65°)

Right Face

A 3-point perspective of a rotated cube: $15^\circ - 75^\circ$

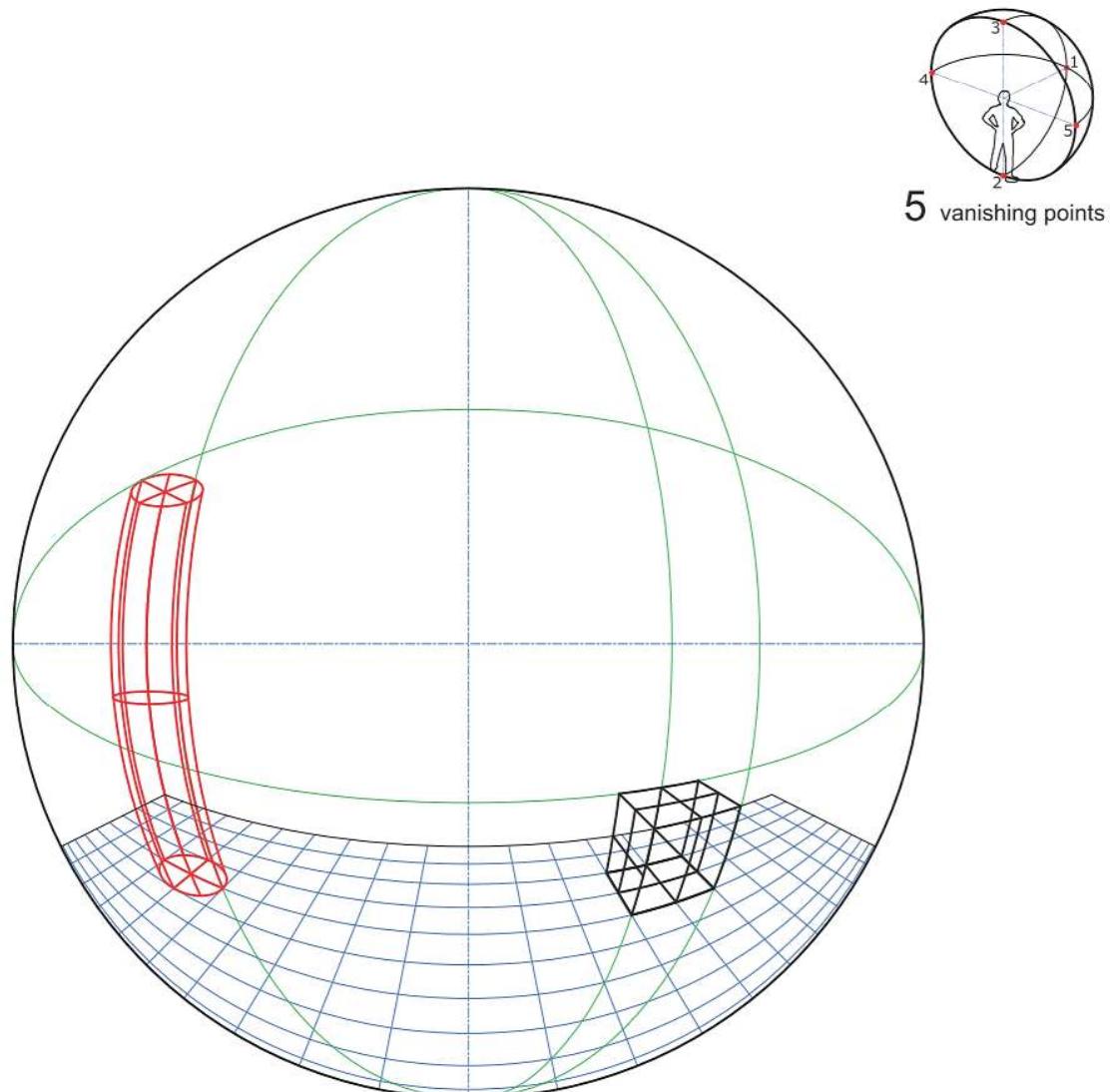


Rotating a cube in three dimensions



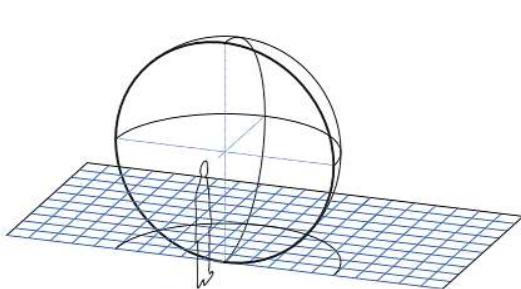
Chapter 5

Curvilinear perspective:
“how to draw” and examples

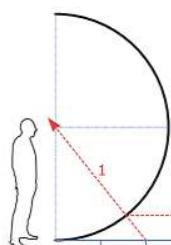


horizontal grid

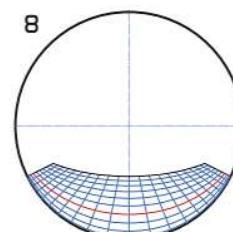
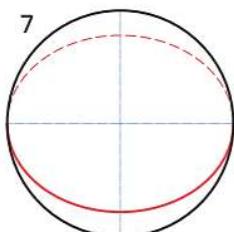
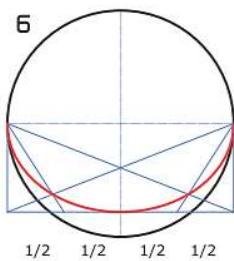
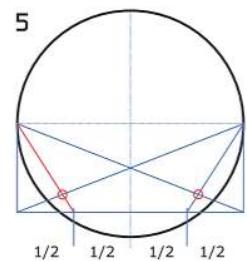
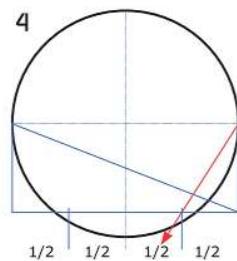
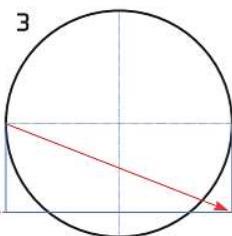
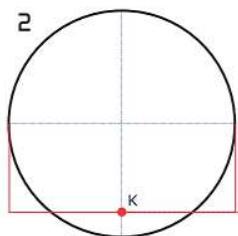
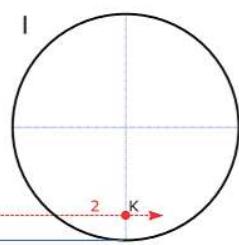
A horizontal line projected on the hemispherical field of view



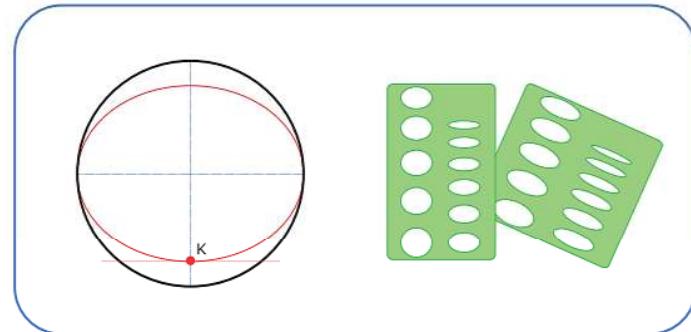
Side



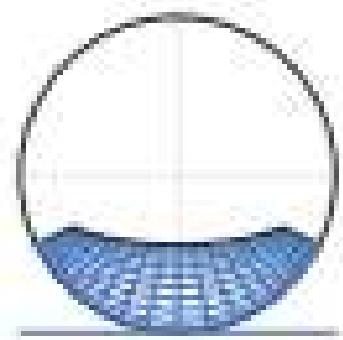
Front



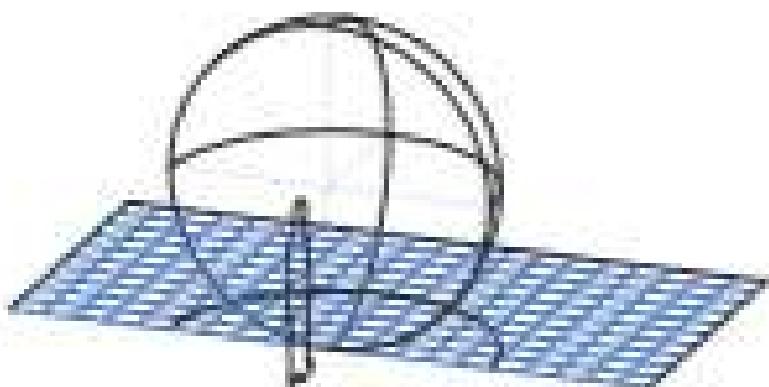
As an alternative to graphical construction, it is also possible to use plastic ellipse templates.



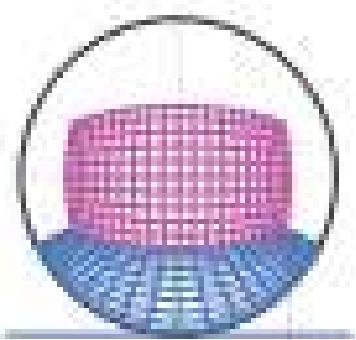
horizontal grid



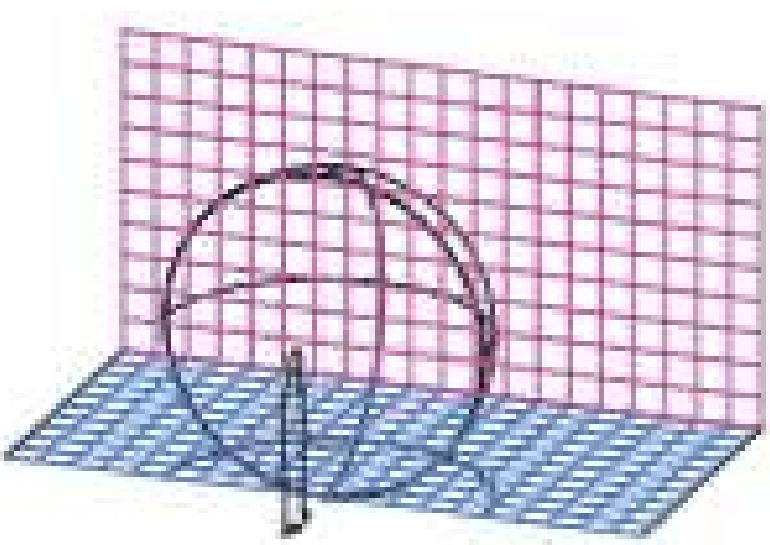
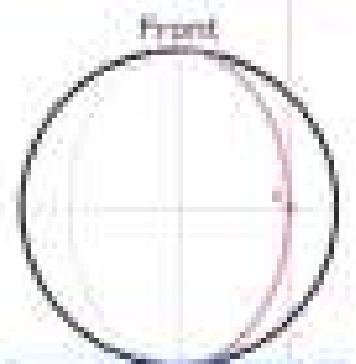
A grid of horizontal lines projected on the hemispherical field of view.



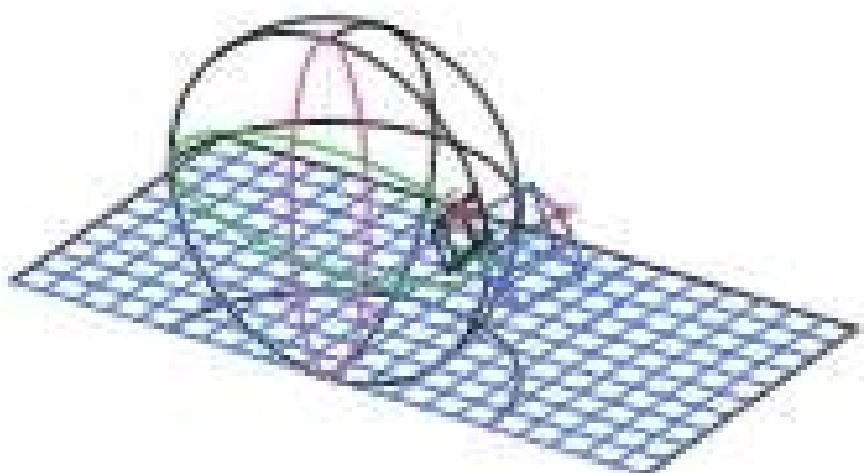
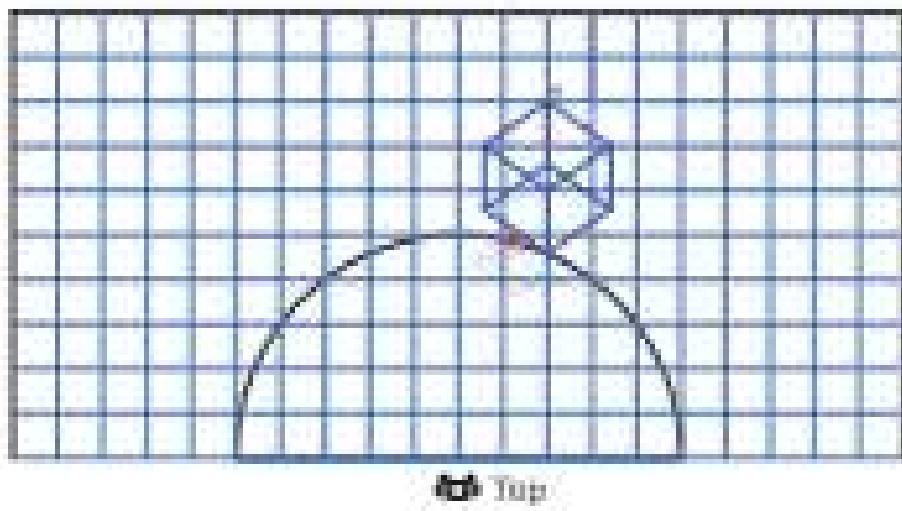
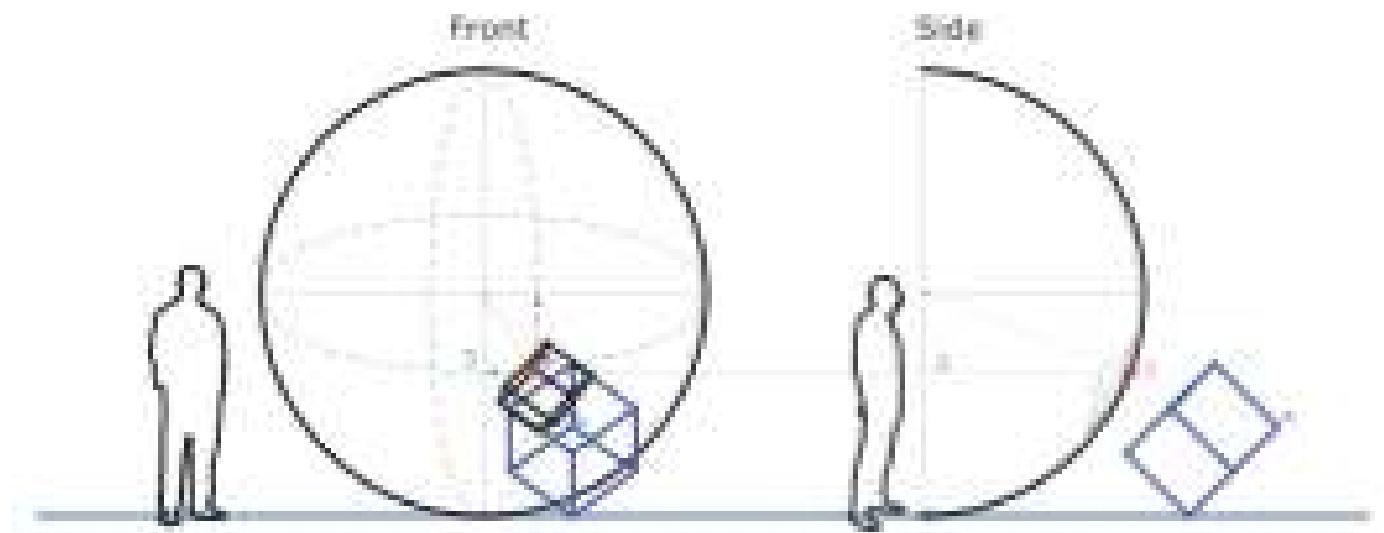
vertical grid



A grid of vertical lines projected on the hemispherical field of view.



How to find any point projected on the hemispherical field of view



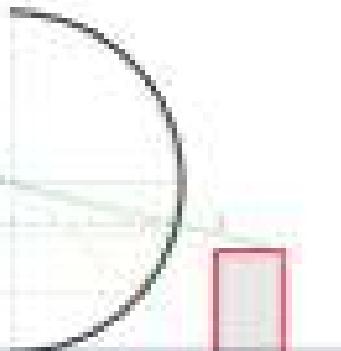


Height and base points projected
on the hemispherical base of shape

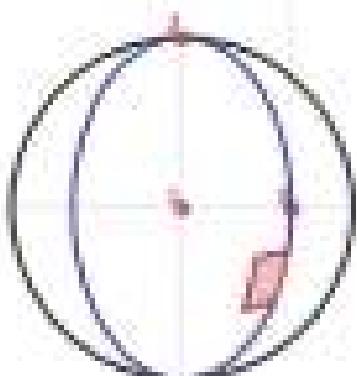
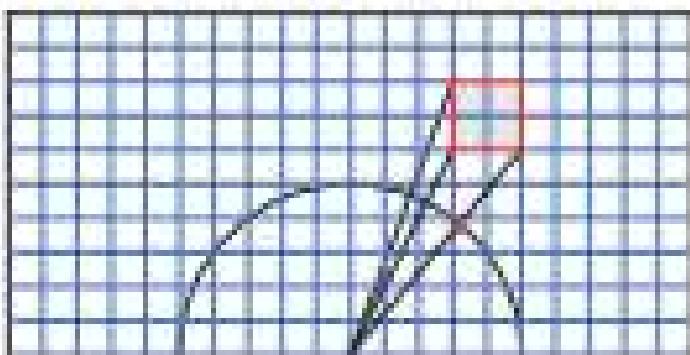
Front



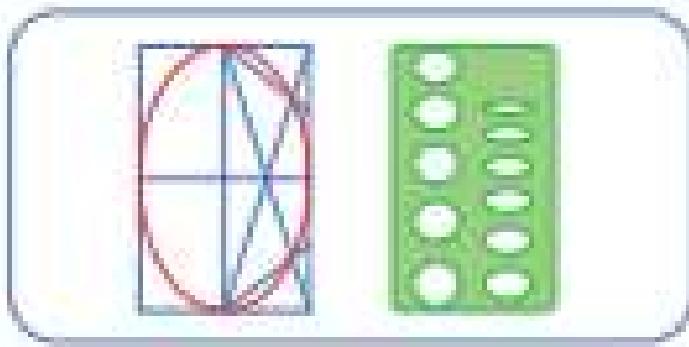
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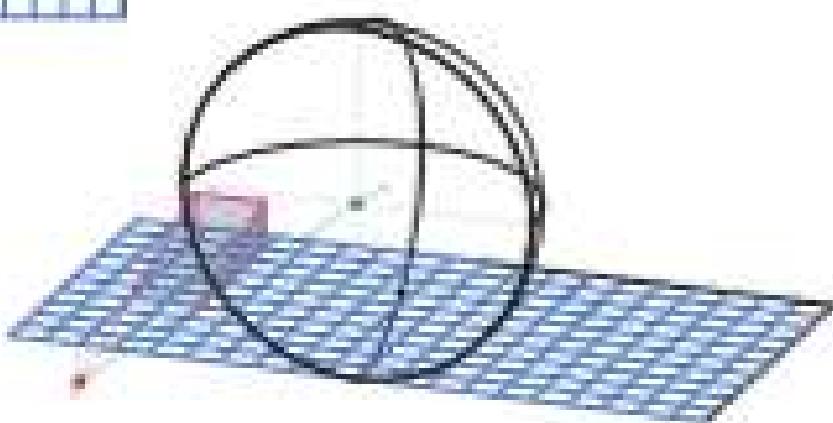
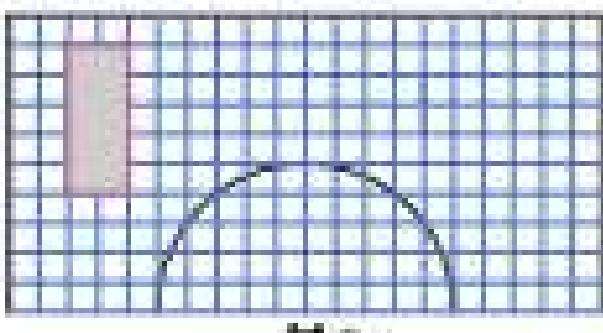
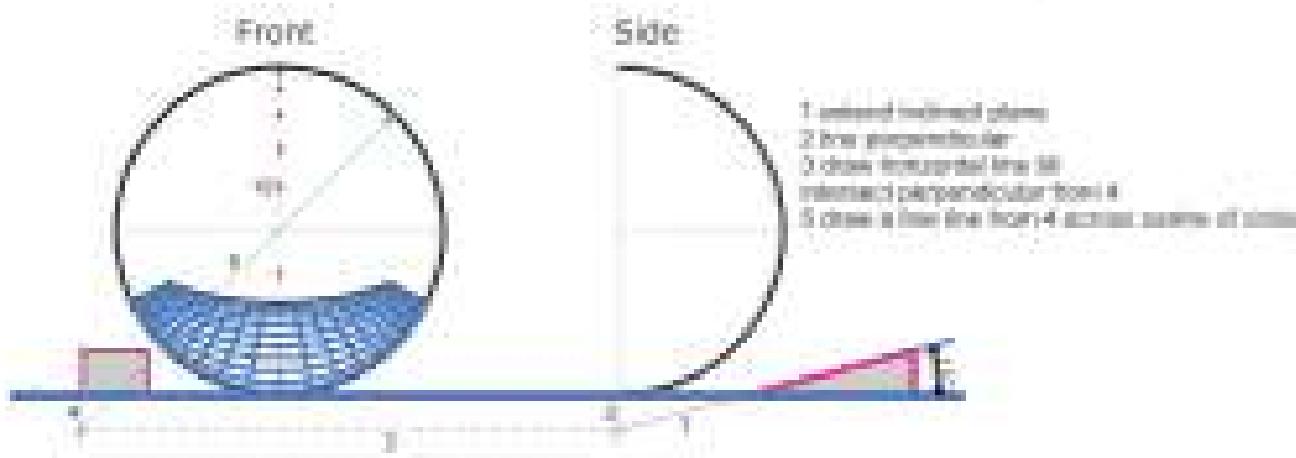
Top



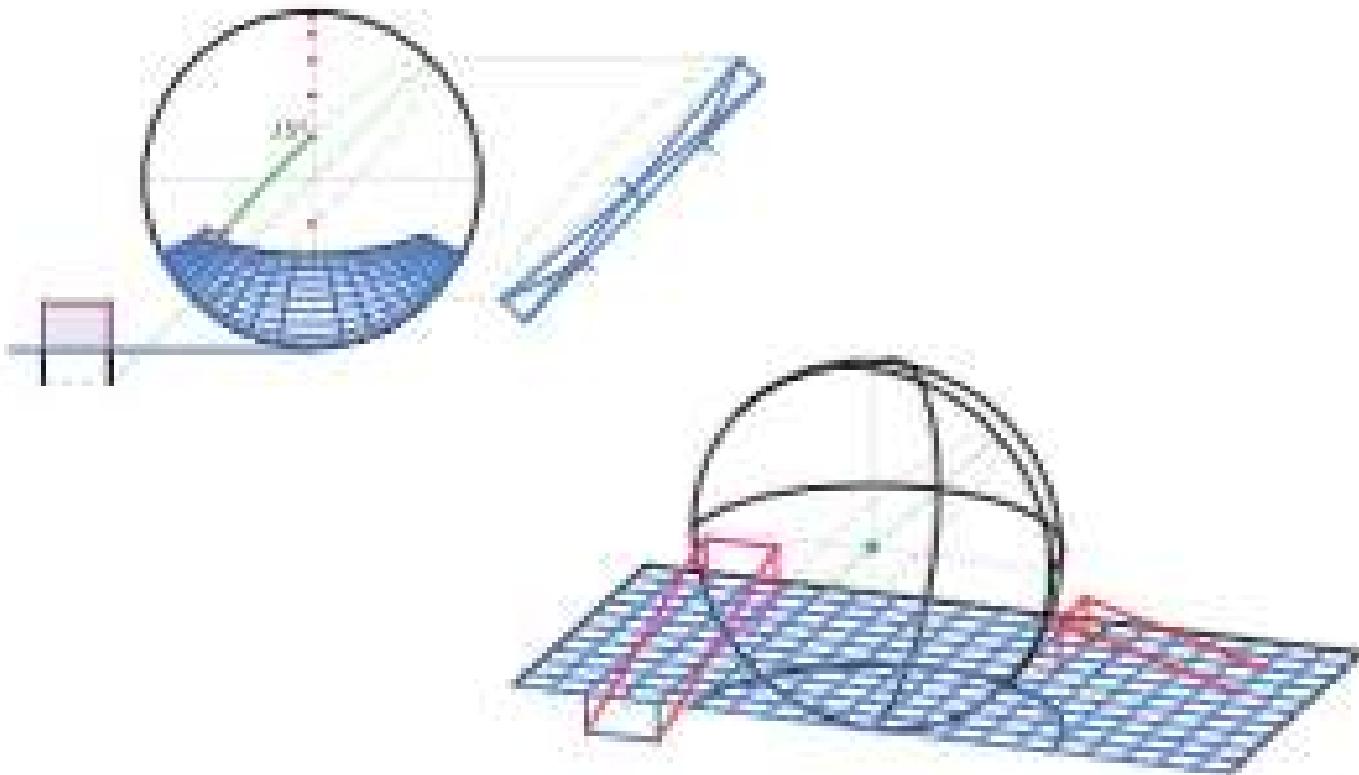
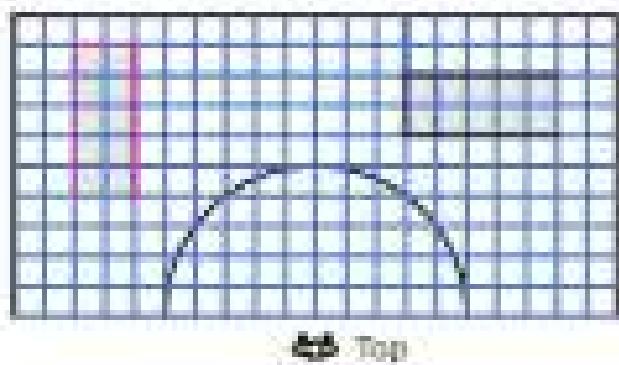
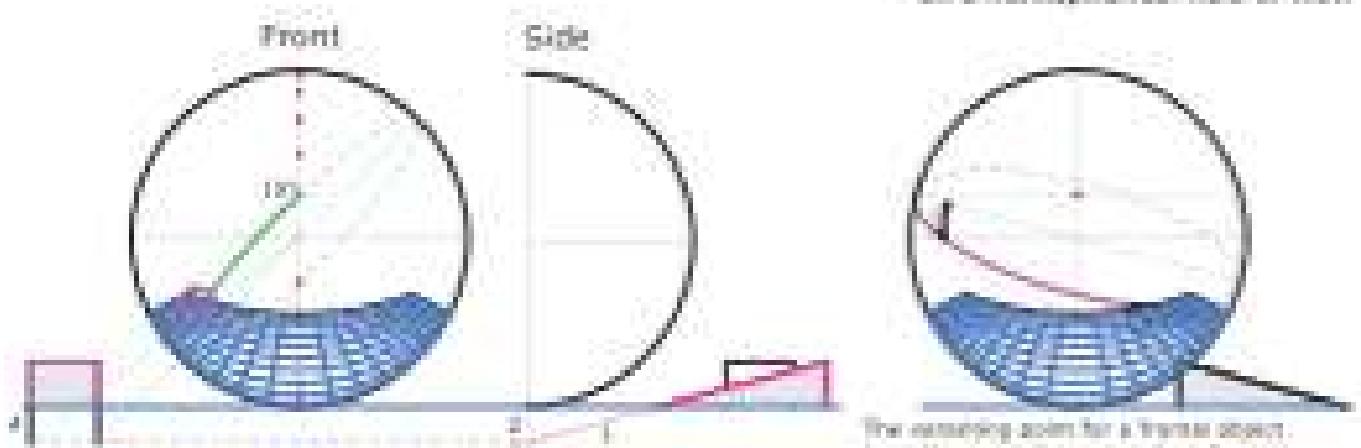
An alternative to graphical construction, it is also possible to use parallel elliptical projections.



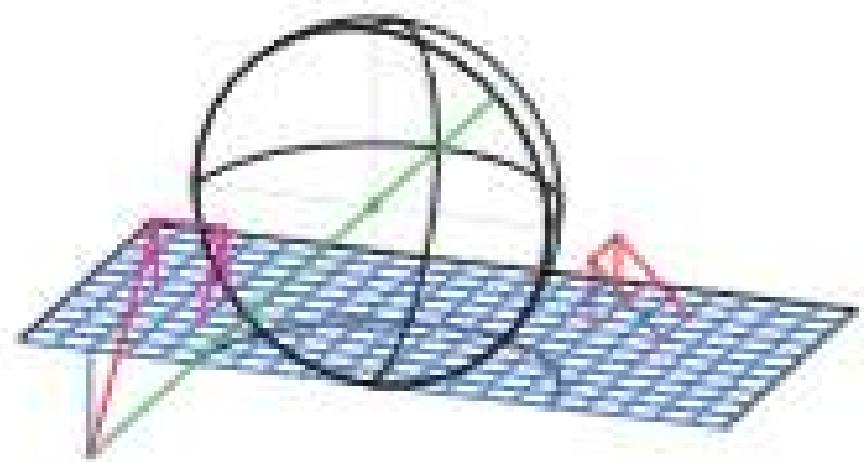
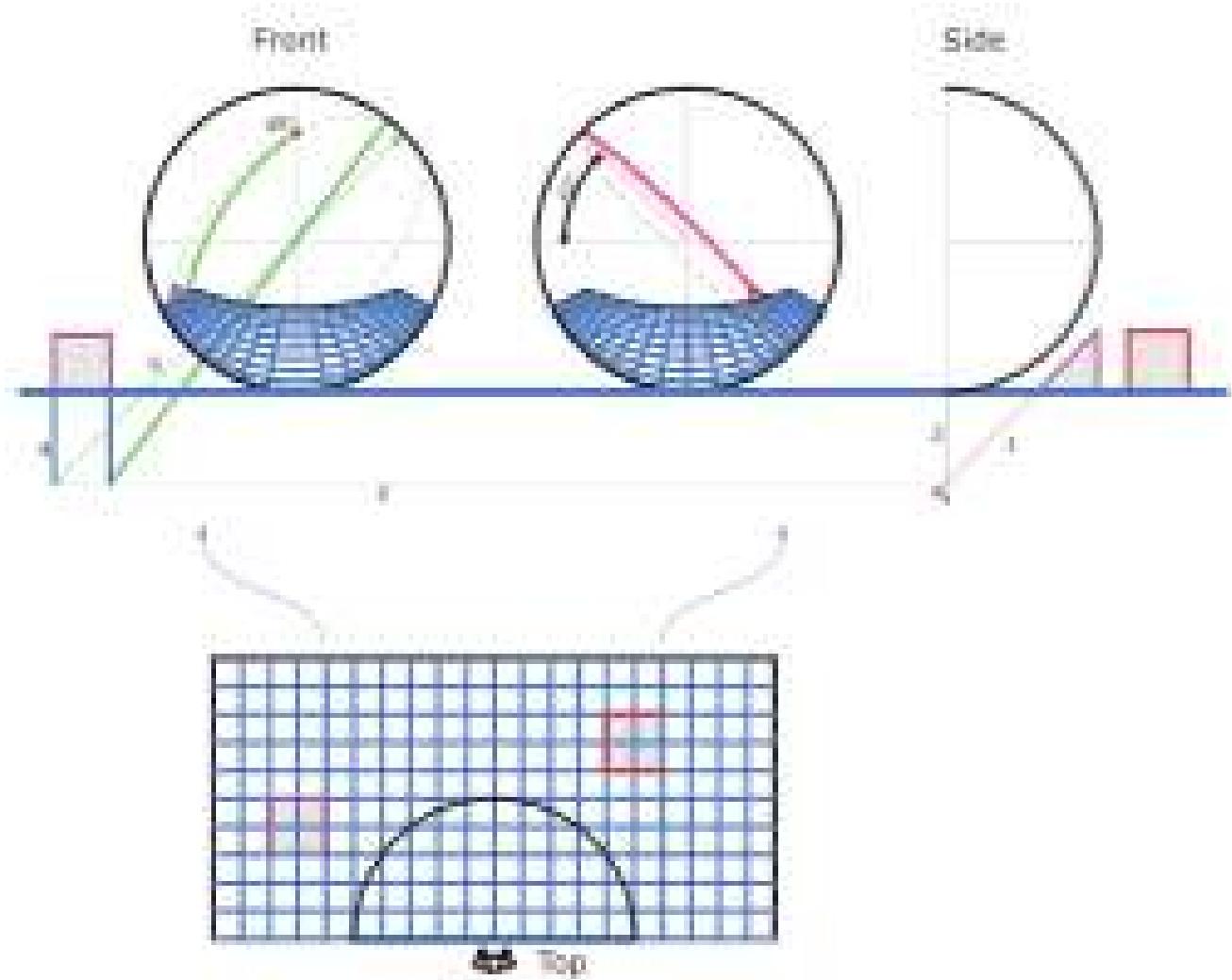
Lines inclined at 35° projected on a hemispherical field of view.



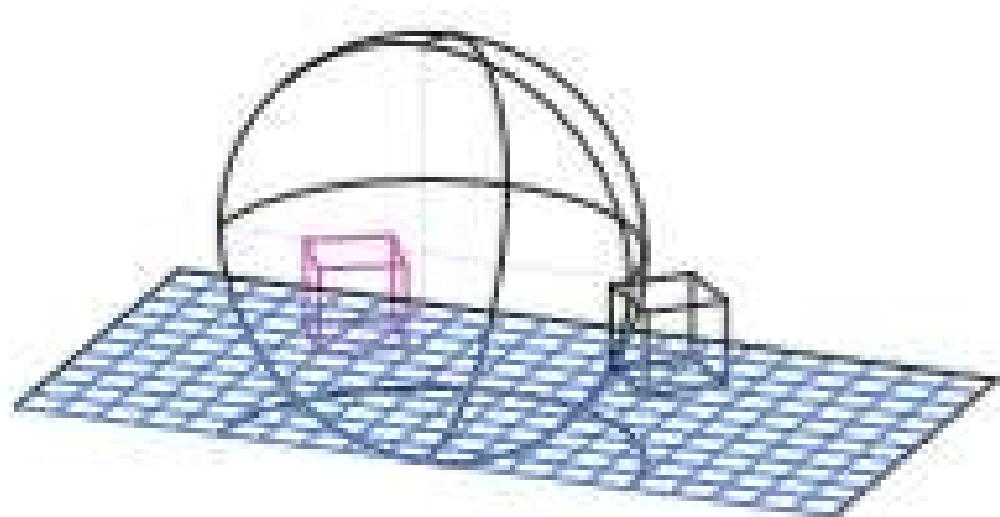
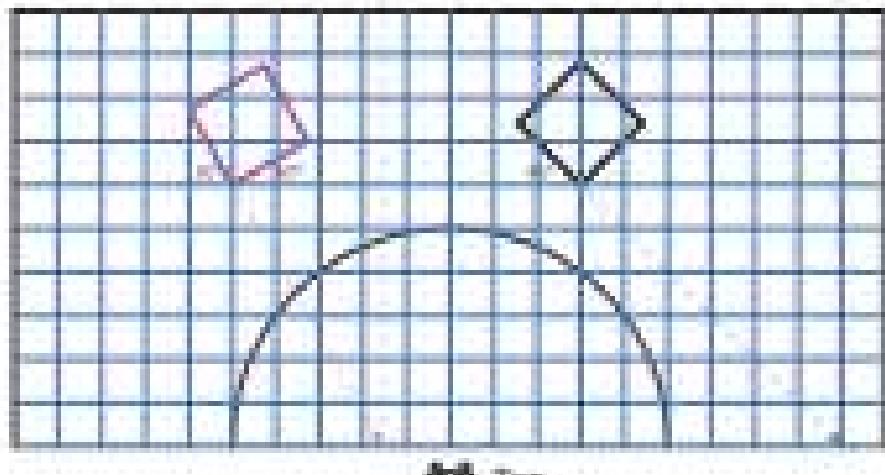
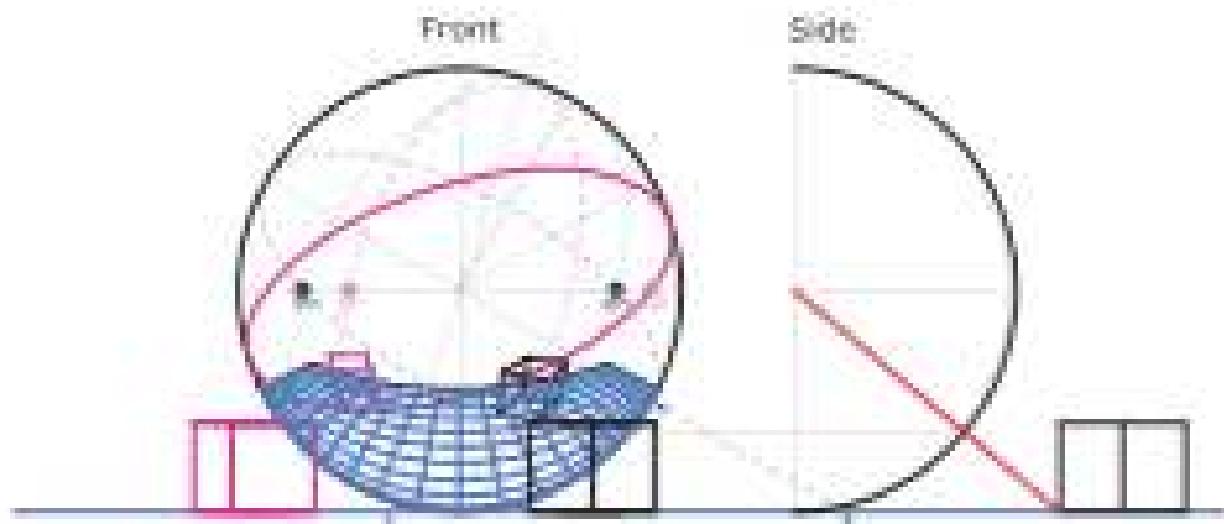
Lines inclined at 15° projected
on a hemispherical field of view



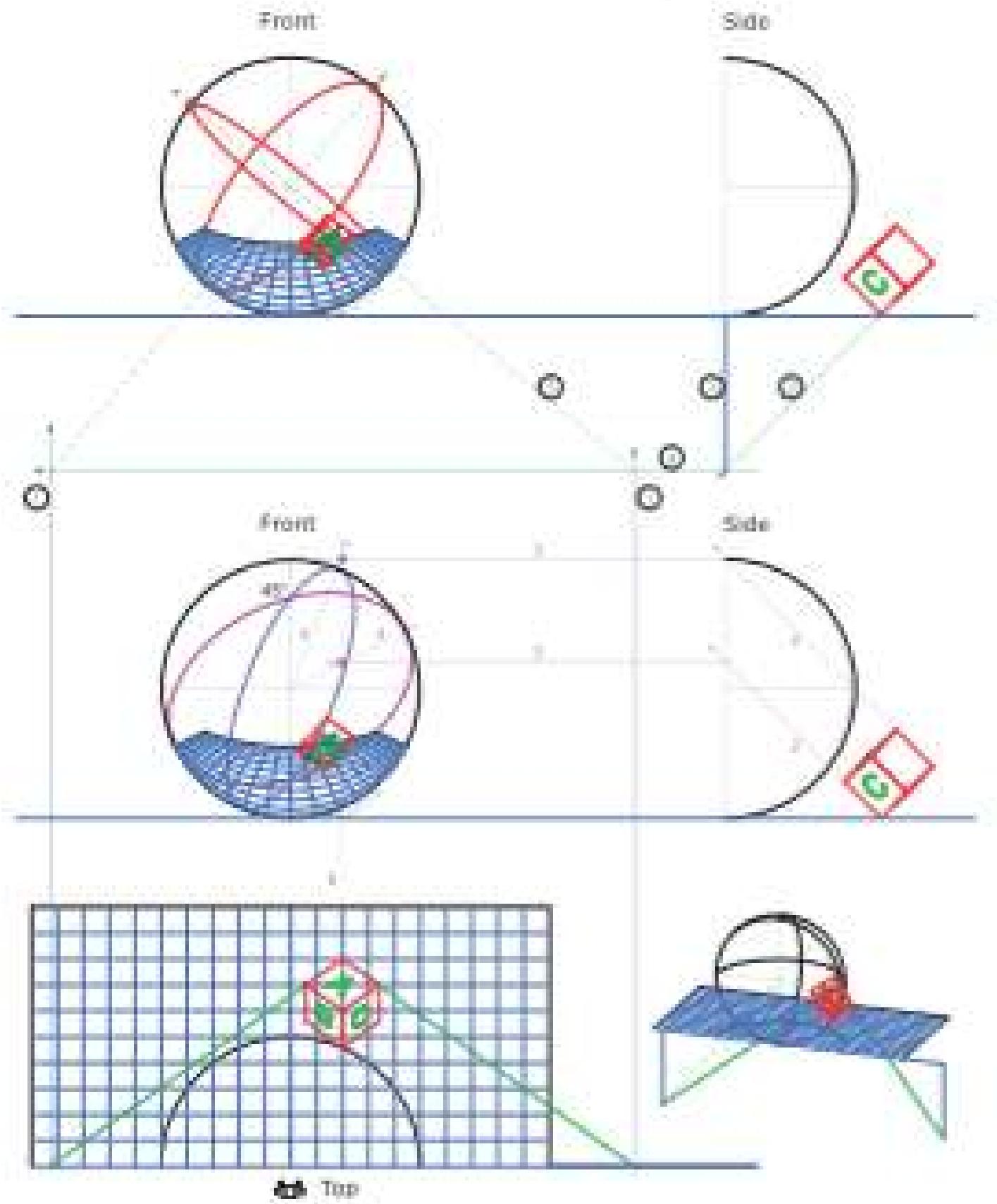
Lines inclined at 45° projected
on a hemispherical field of view



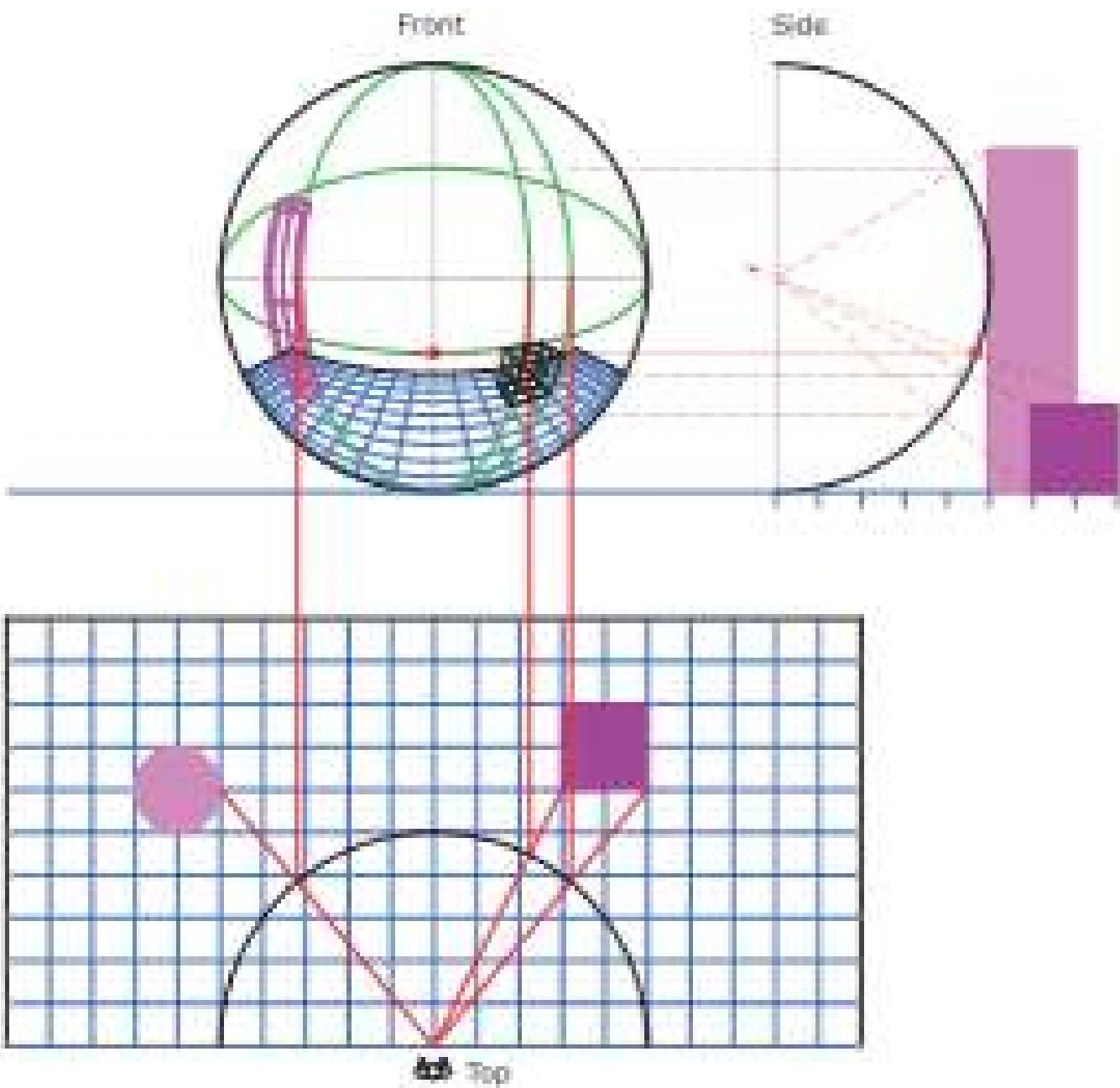
Objects in Two-point perspective projected on the hemispherical field of view



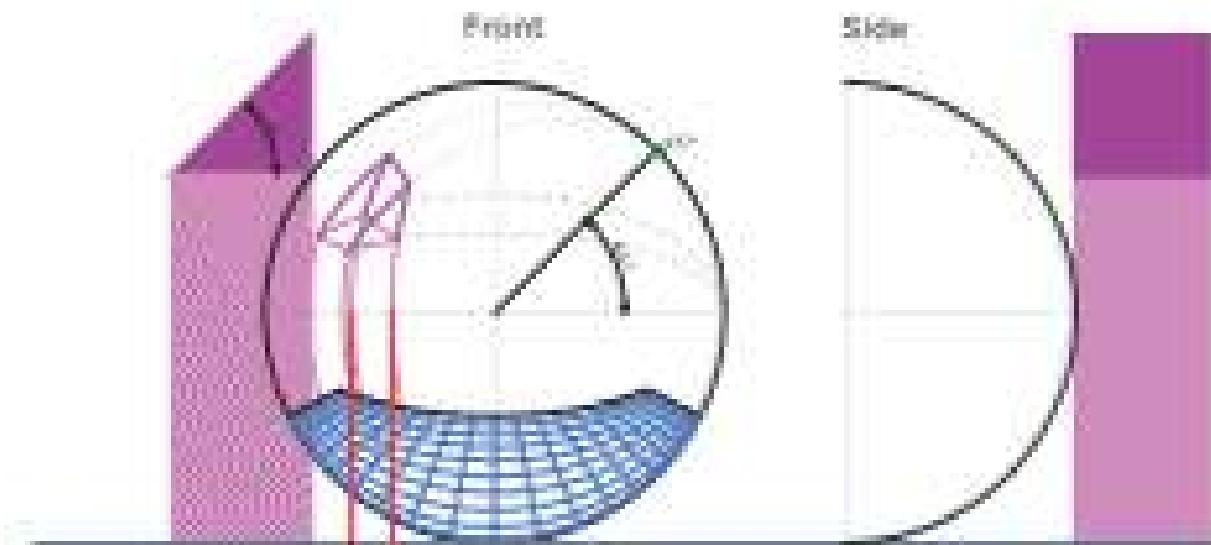
Objects in Three-point perspective projected on the hemispherical field of view



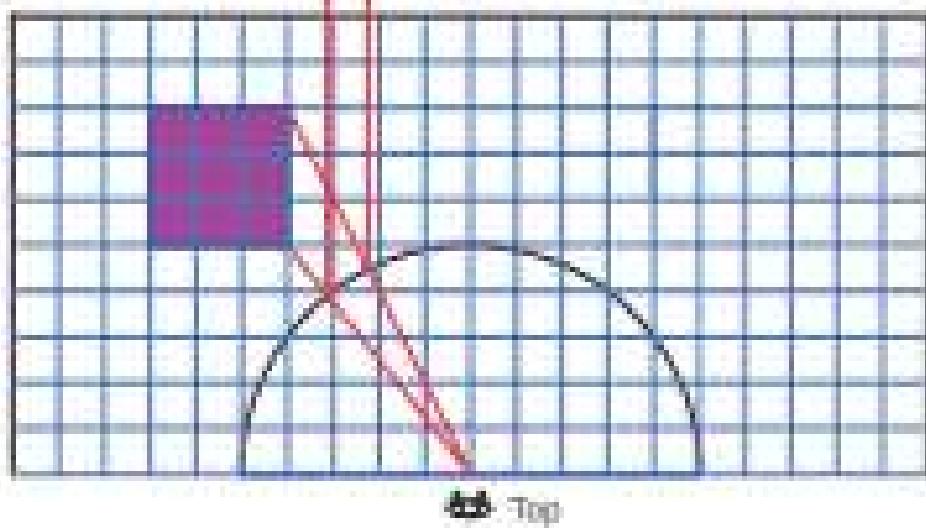
A cube and a cylinder projected on a hemispherical field of view



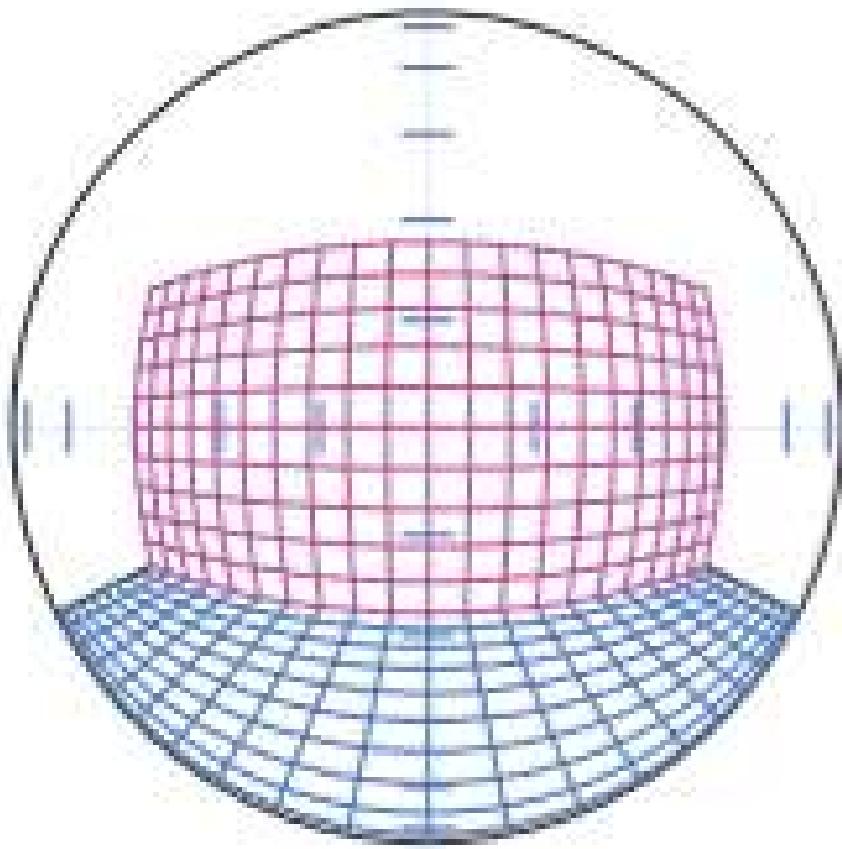
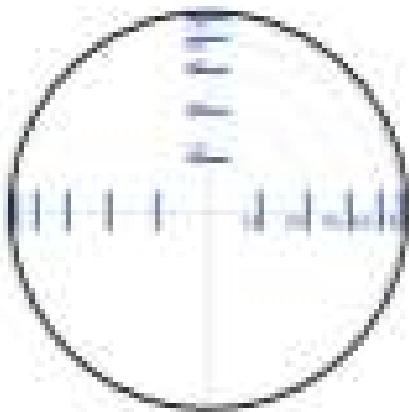
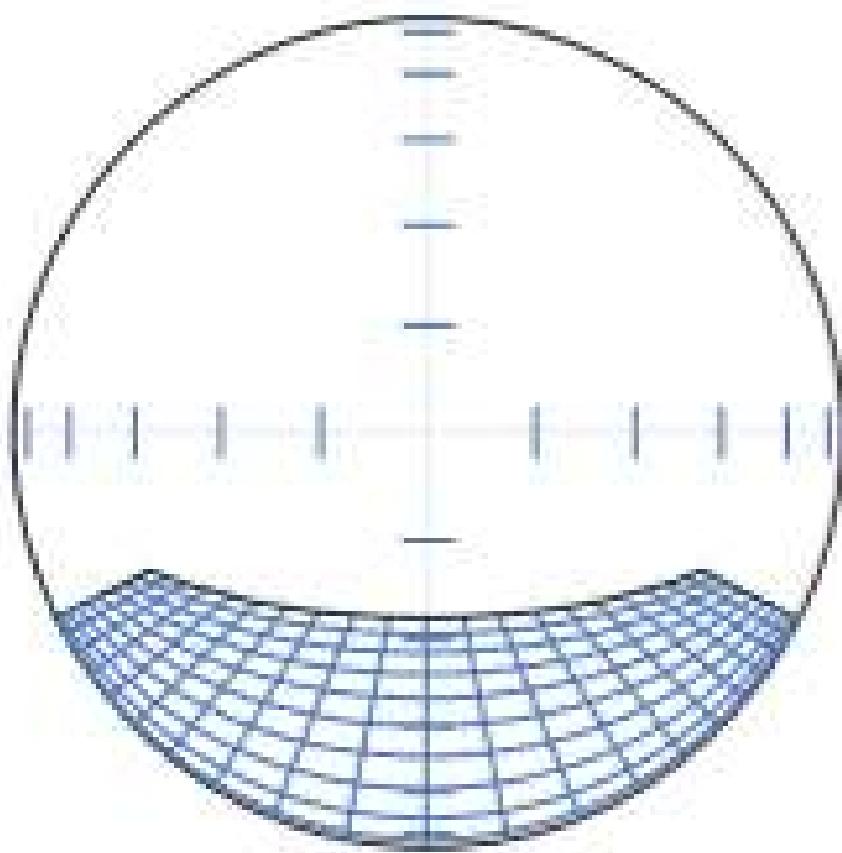
Two geometric solids projected
on a hemispherical field of view



The vanishing point for a frontal object
is on the circumference, not on the axis.

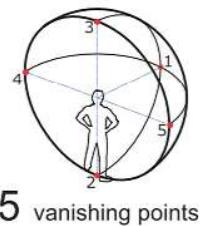


Perspective grids

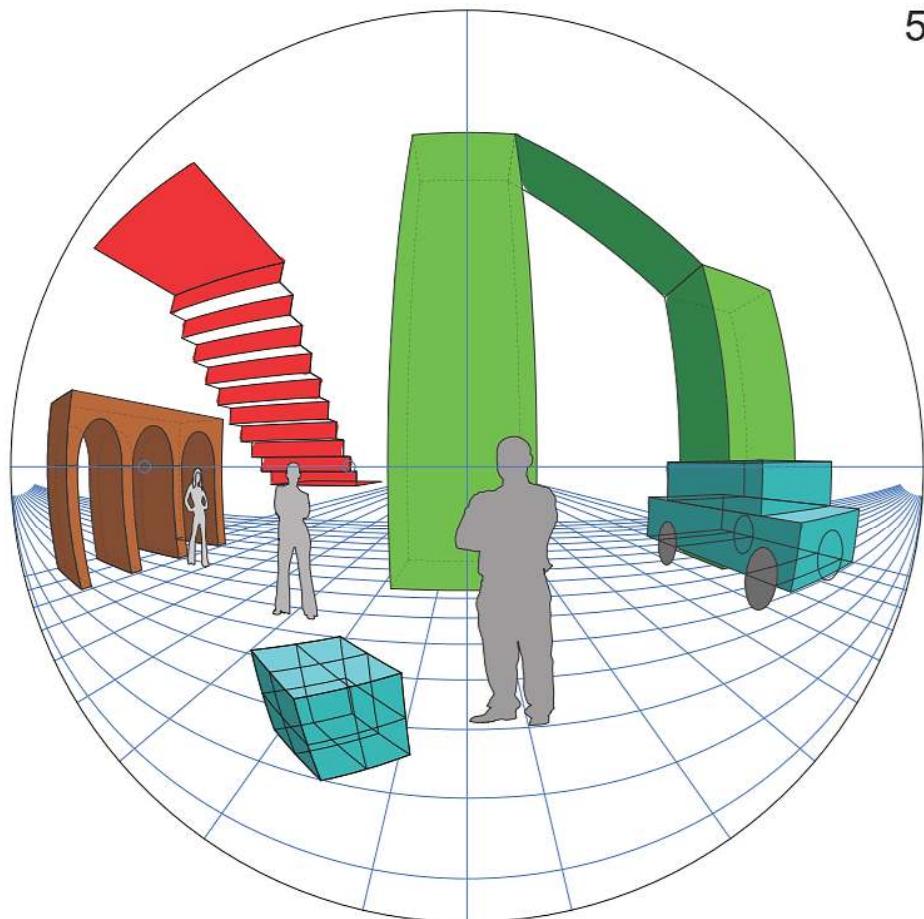


Chapter 6

Curvilinear perspective:
5 vanishing points with examples

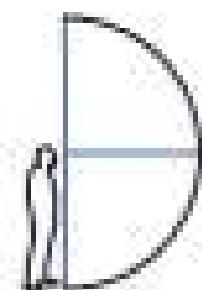


5 vanishing points

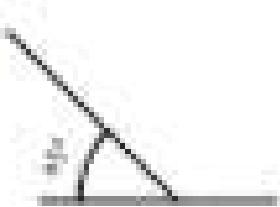
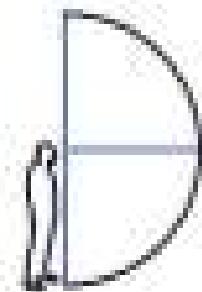
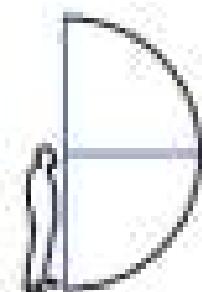
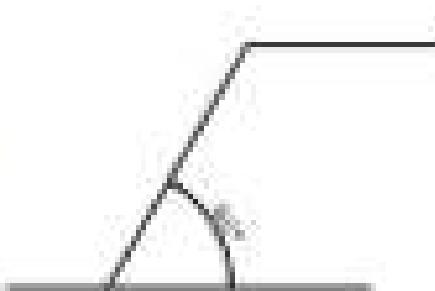
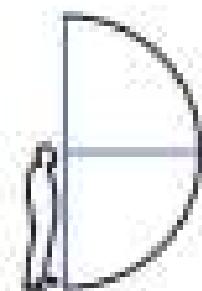
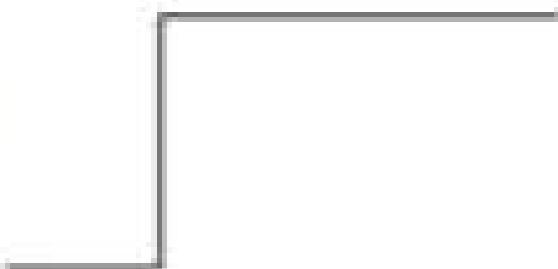


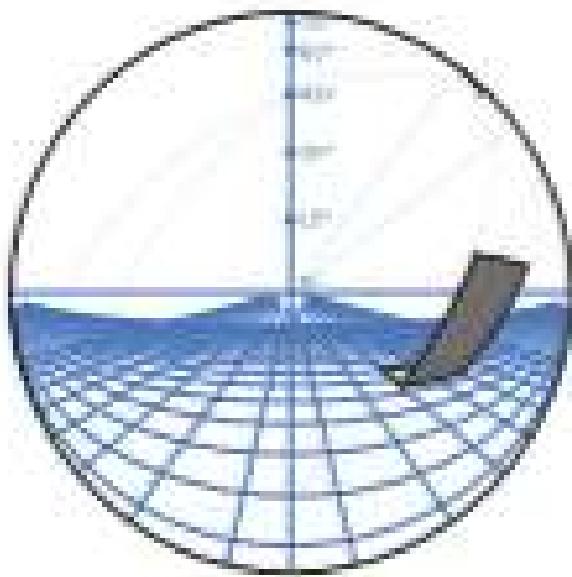
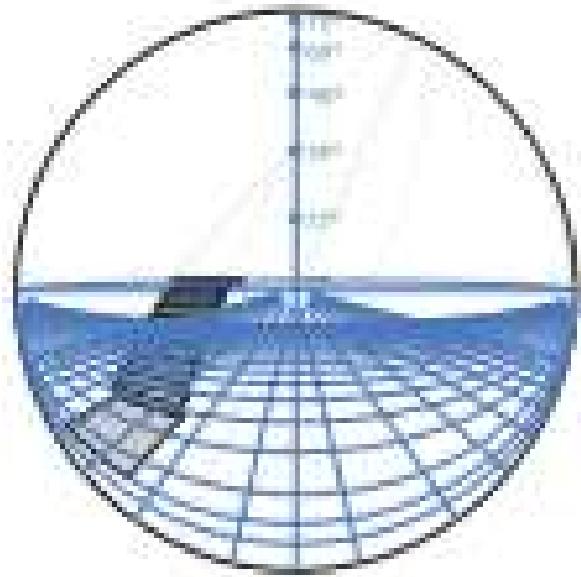
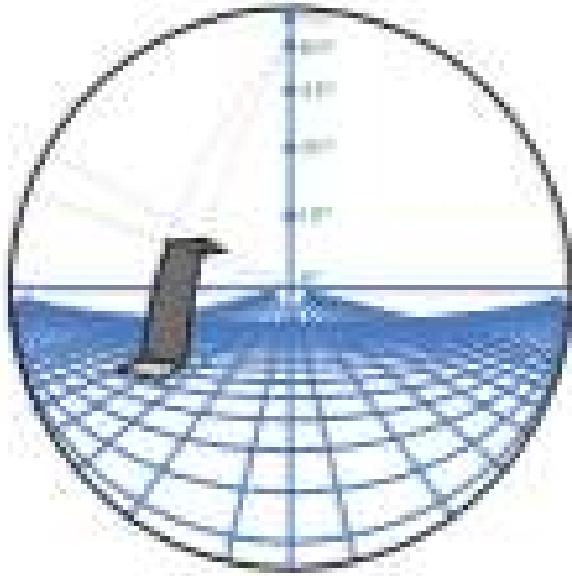
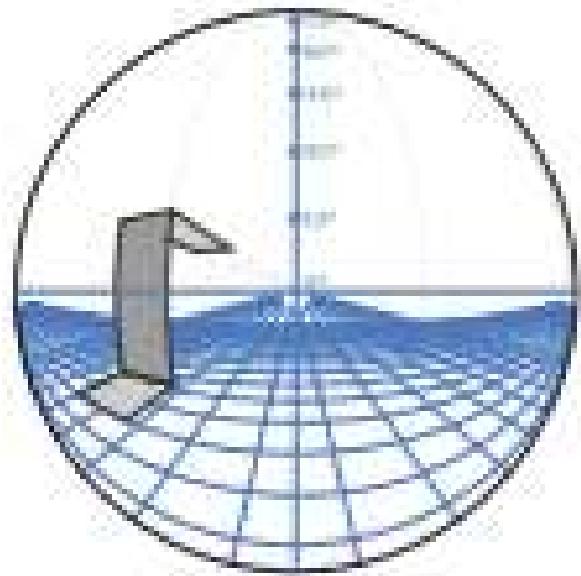
Objects Related to the Hemispherical Prism of vision

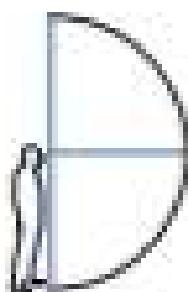
Front



Side



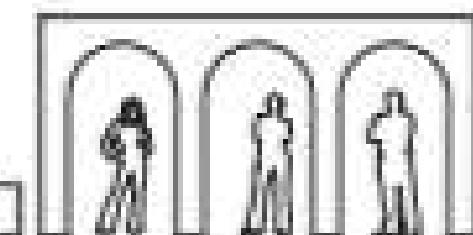
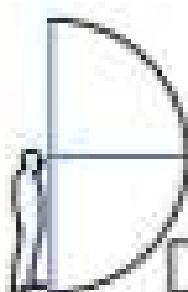
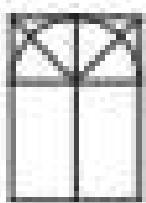
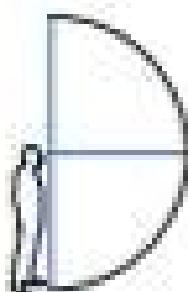
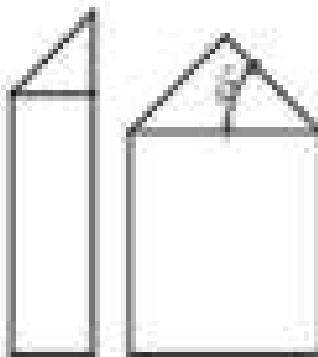
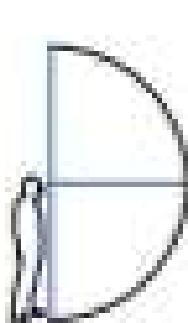
Objects Lateral to the Stereographical Field of view

Objects lateral to the hemispherical field of vision

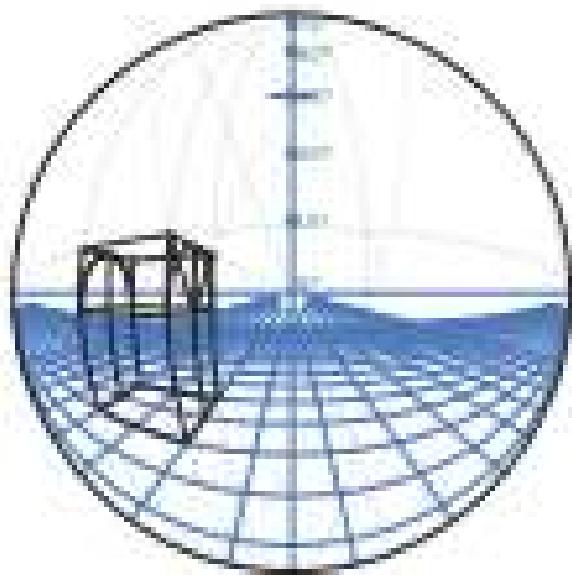
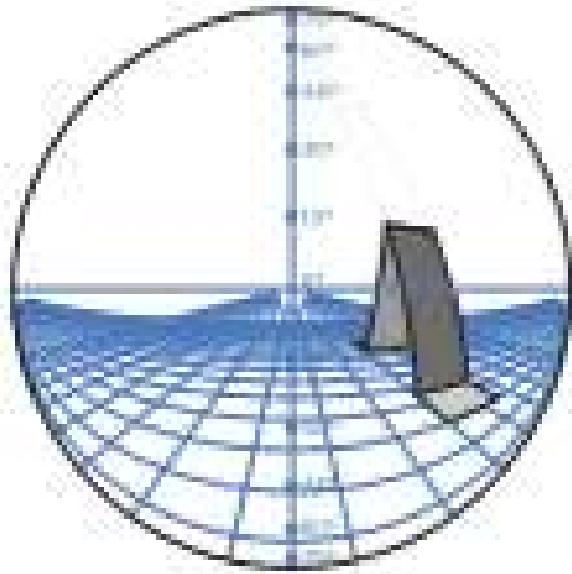
Front:



Side:

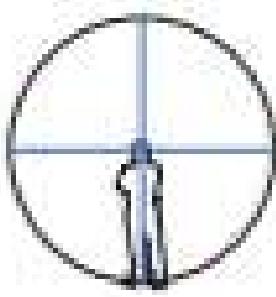


Objects Lined up to the Hemispherical Field of Vision

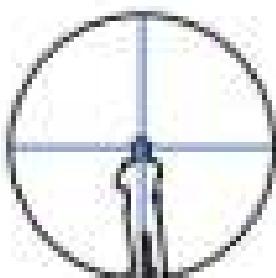
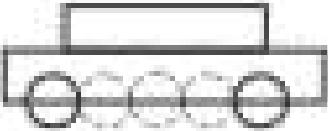
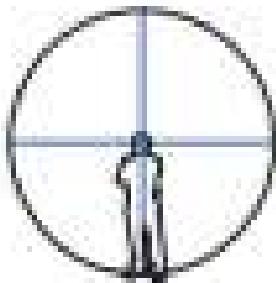
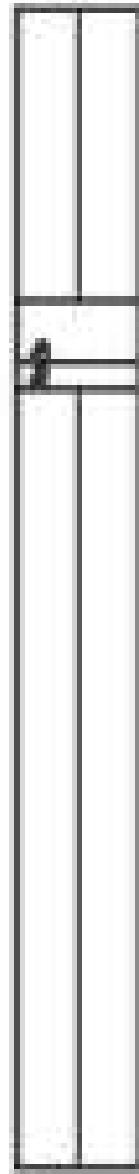
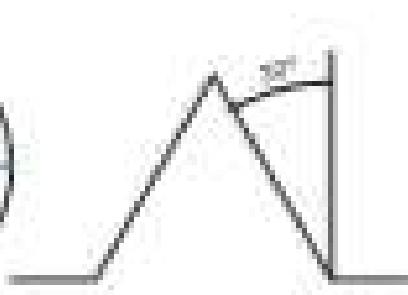
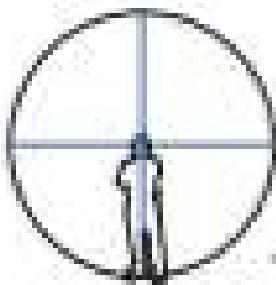
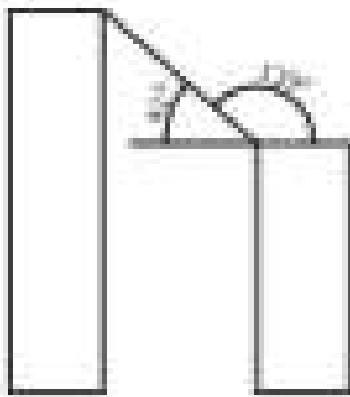


Objects frontal to the hemispherical field of view

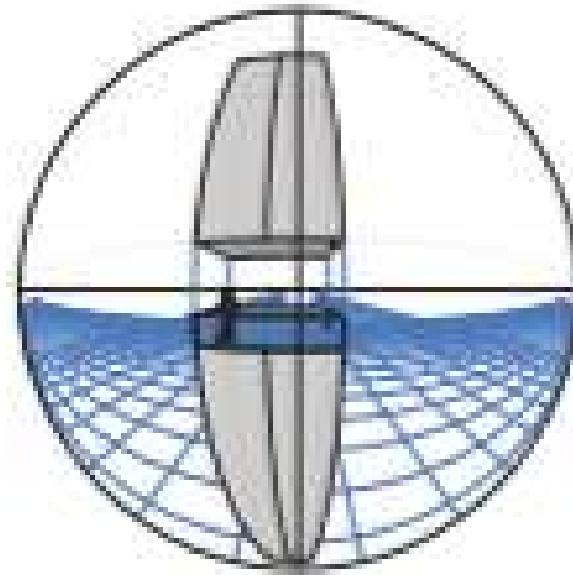
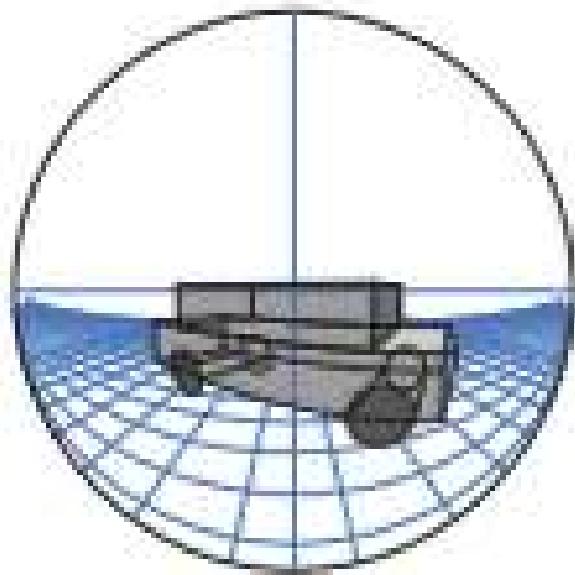
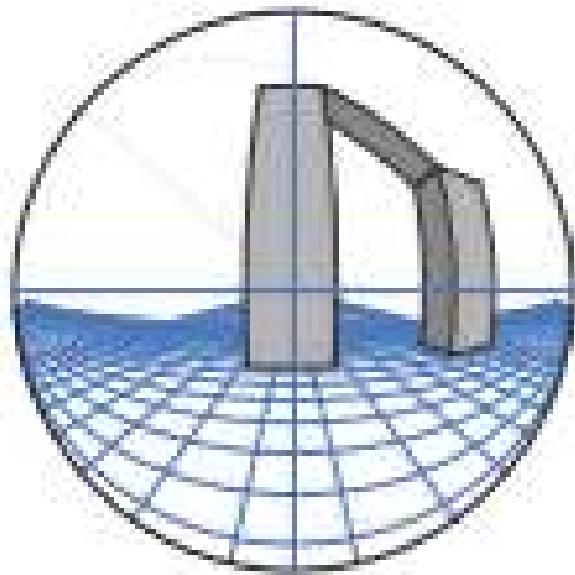
Front



Front

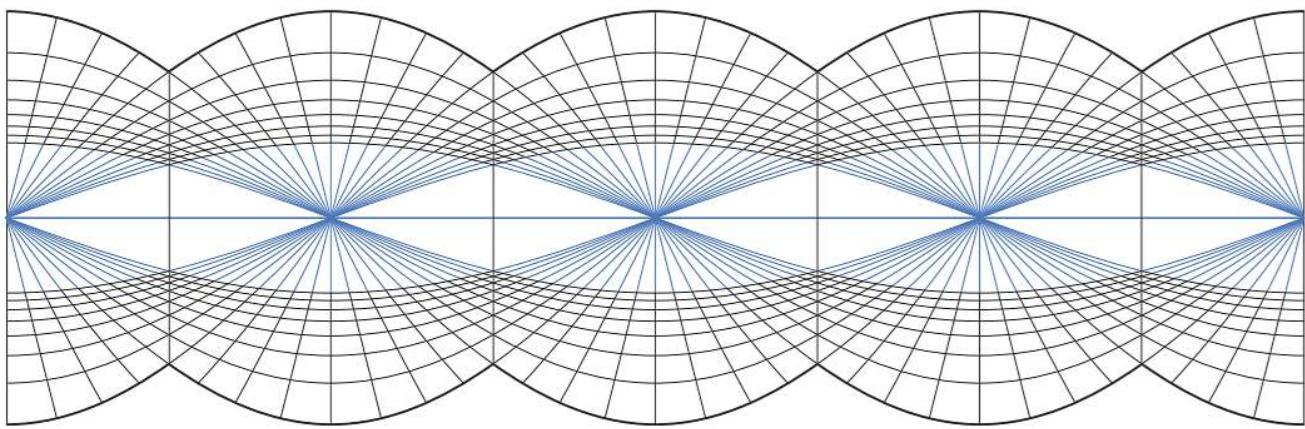


Objects Present in the Suboptimal Field of View



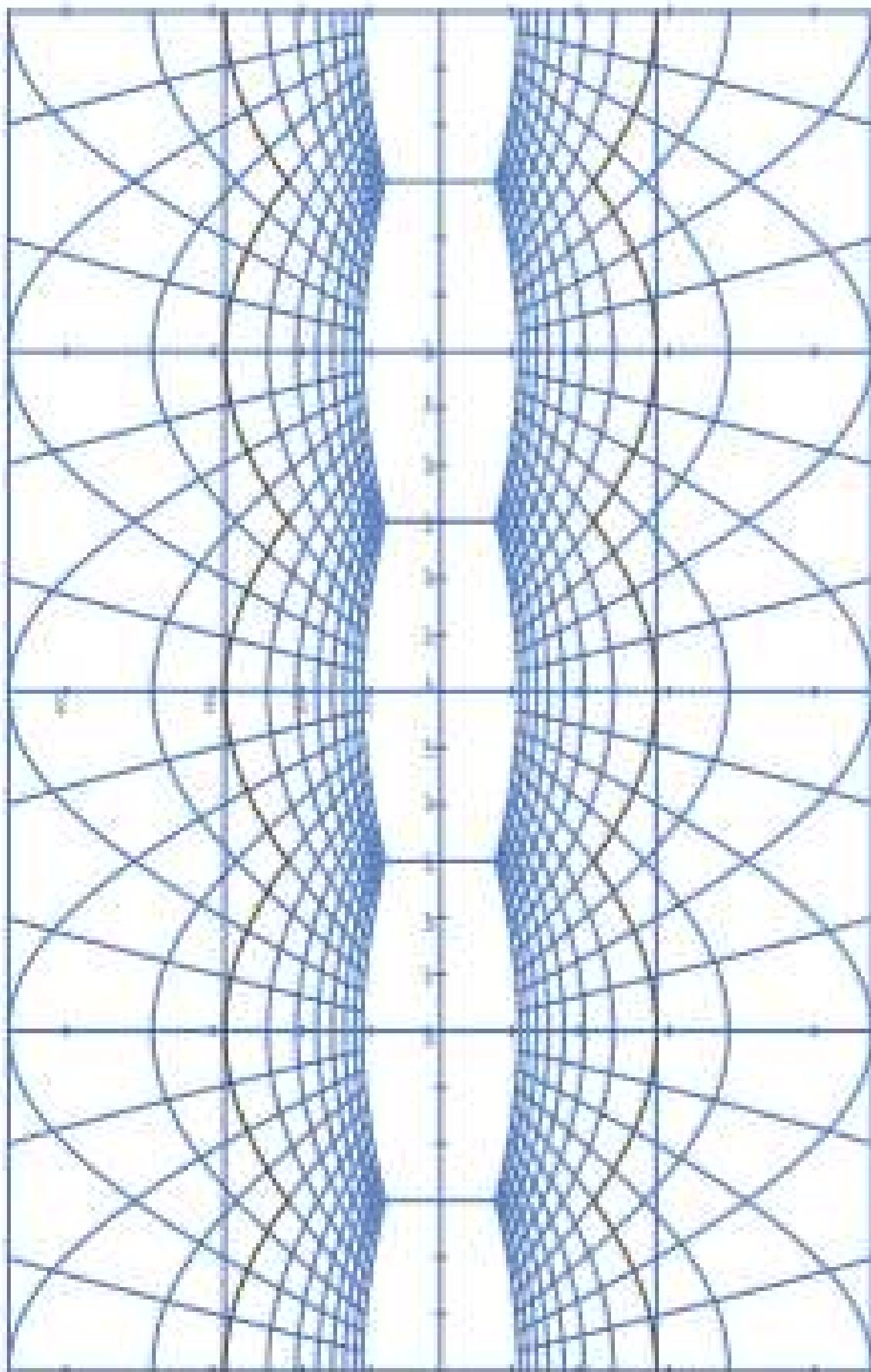
Appendix

Perspective charts

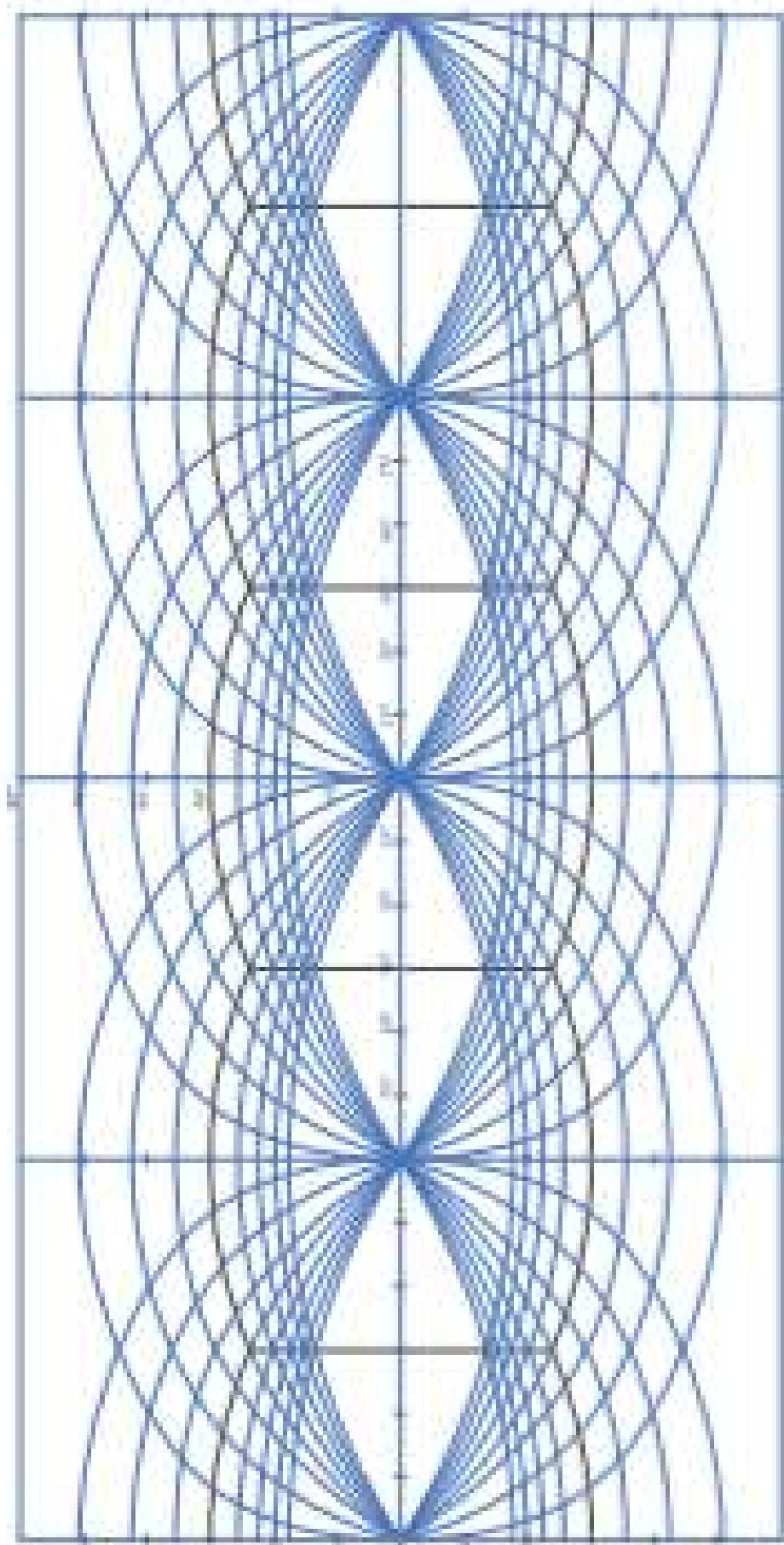


Equirectangular Projection

SIMPLE CYLINDRICAL GRID



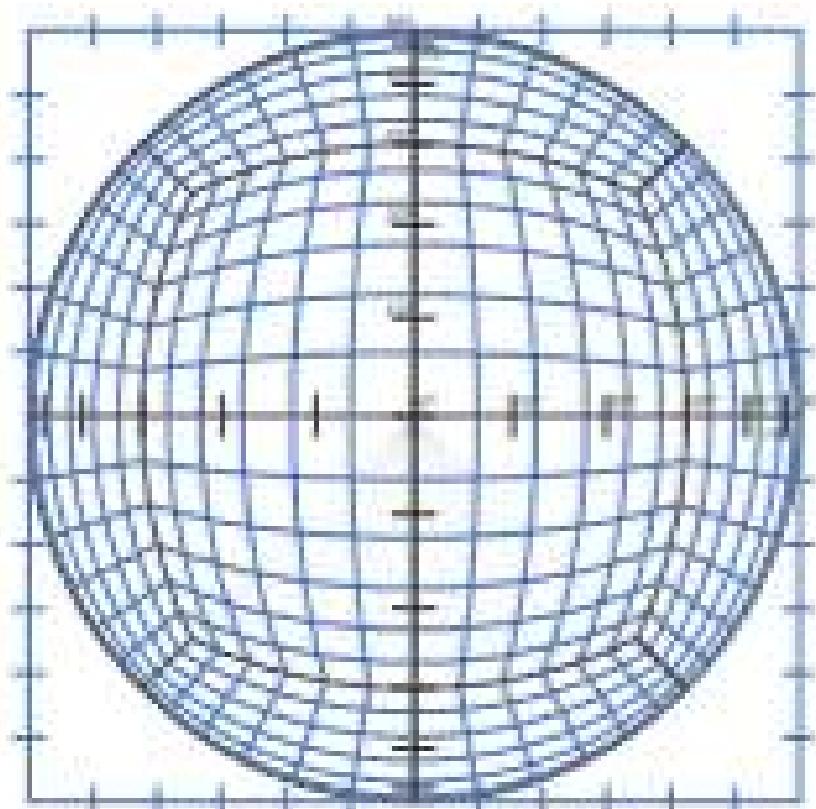
EQURECTANGULAR CYLINDRICAL GRID



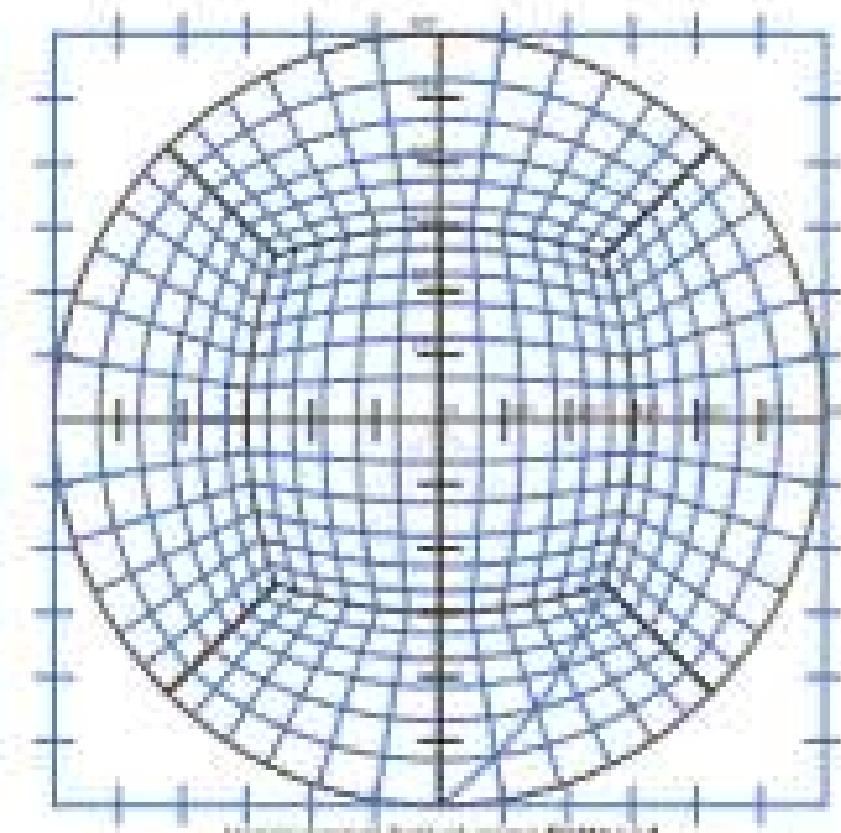
CYLINDRICAL PERSPECTIVE

Projection of a cube on the hemispherical field of vision

Grid 98°



Hemispherical field of vision unwarped
(Brenner et al., 2001)

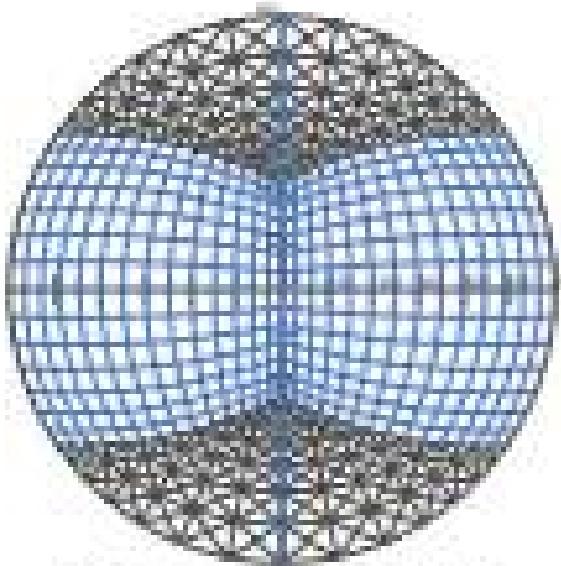


Hemispherical field of vision **Pattened**
Perspective-correct warping of the boundaries are shown

CYLINDRICAL PERSPECTIVE

Projection of a cube on the hemispherical field of vision

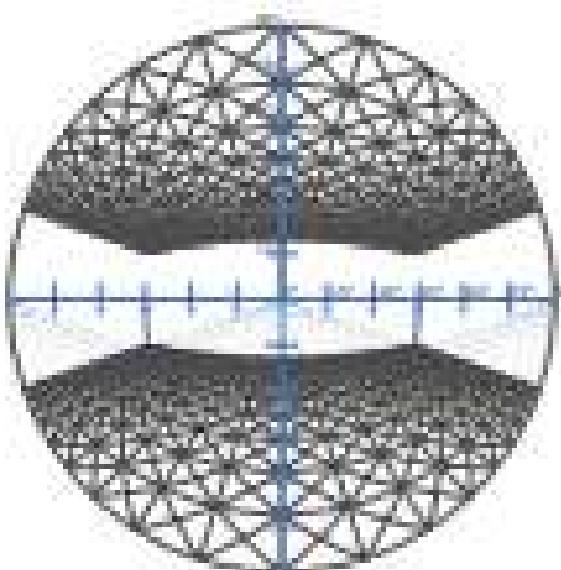
(Grid 45°)



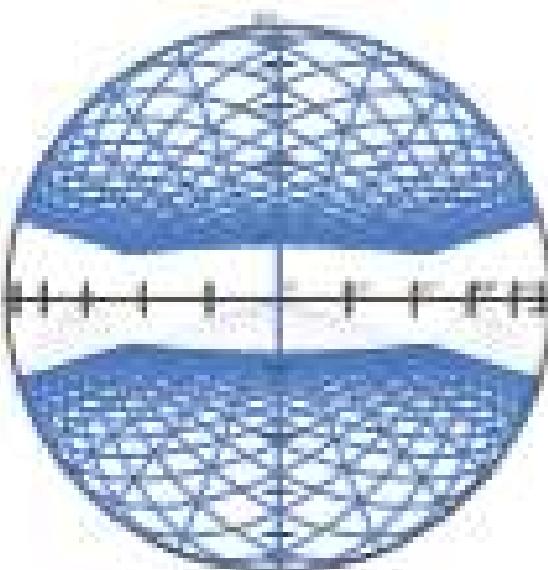
Hemispherical field of vision flattened
(unwrapping and flattening of the hemisphere on a sheet)



Hemispherical field of vision centered
(hemisphere centered 3D)



Hemispherical field of vision flattened
(unwrapping and flattening of the hemisphere on a sheet)

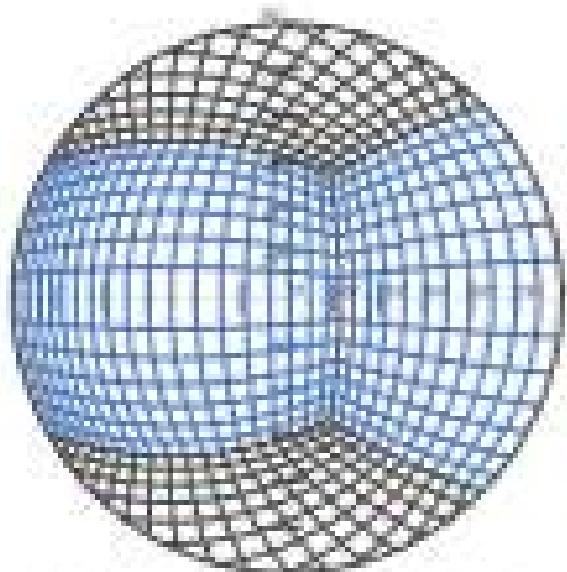


Hemispherical field of vision centered
(hemisphere centered 3D)

CYLINDRICAL PERSPECTIVE

Projection of a cube on the hemispherical field of vision

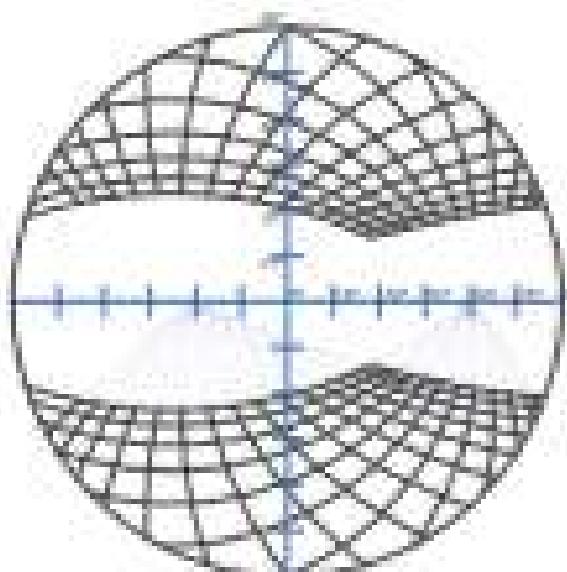
Grid 38°-69°



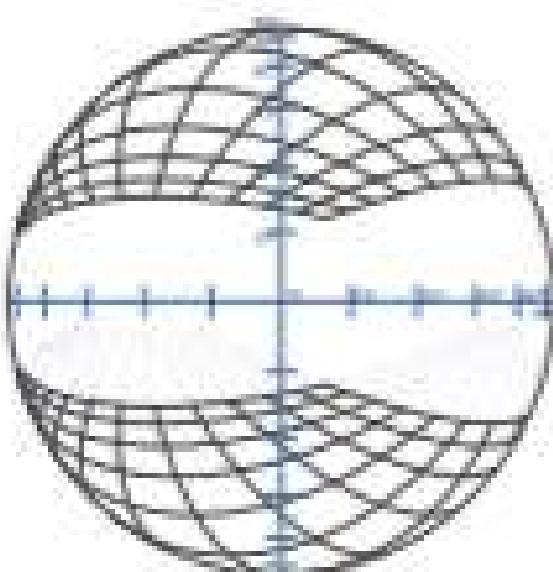
Hemispherical Field of vision flattened
(Unfolding and flattening of the hemisphere on a sheet)



Hemispherical Field of vision curved
(Unfolding curved 3D)



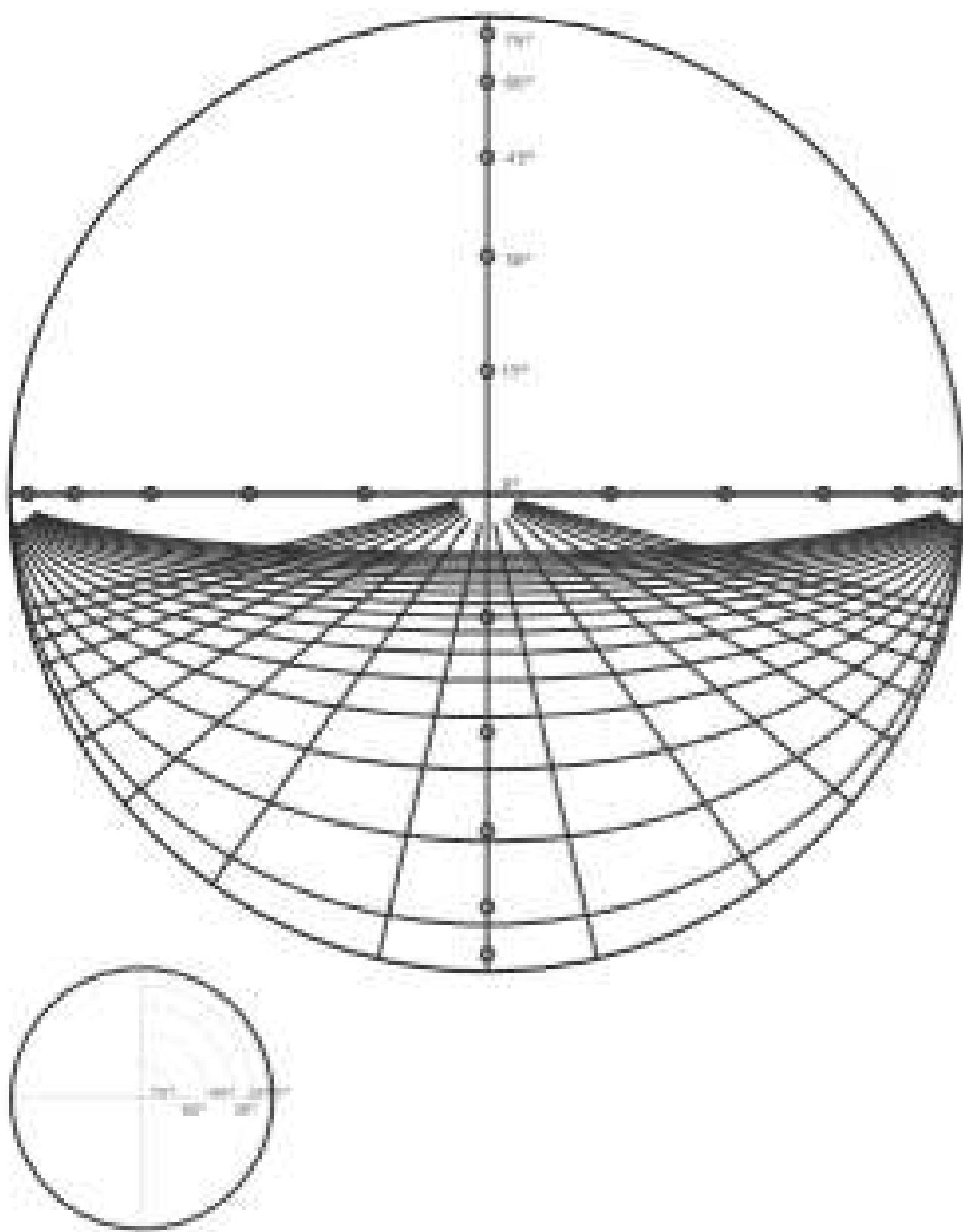
Hemispherical Field of vision flattened
(Unfolding and flattening of the hemisphere on a sheet)



Hemispherical Field of vision curved
(Unfolding curved 3D)

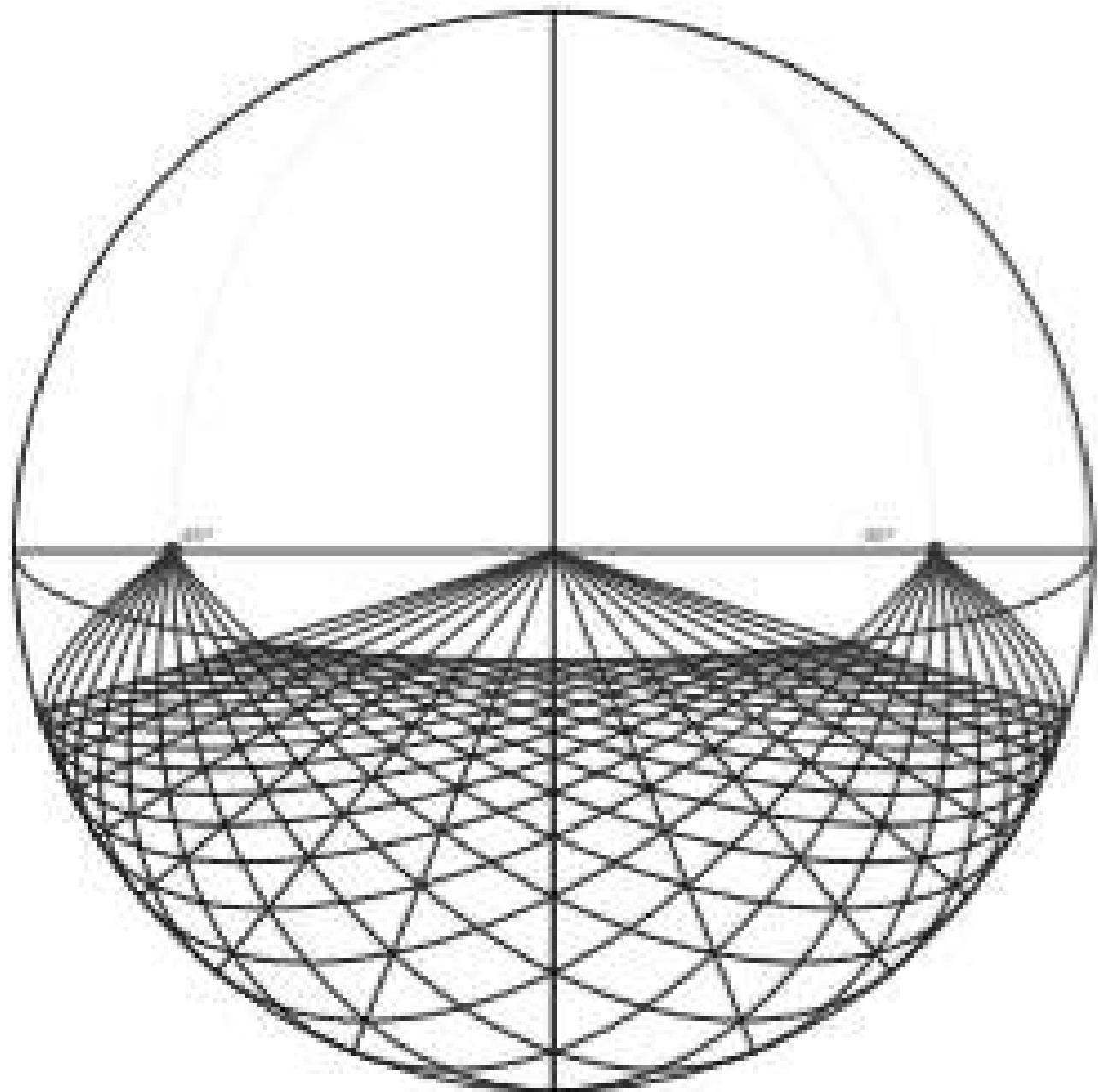
CURVILINEAR PERSPECTIVE

Perspective chart 90°



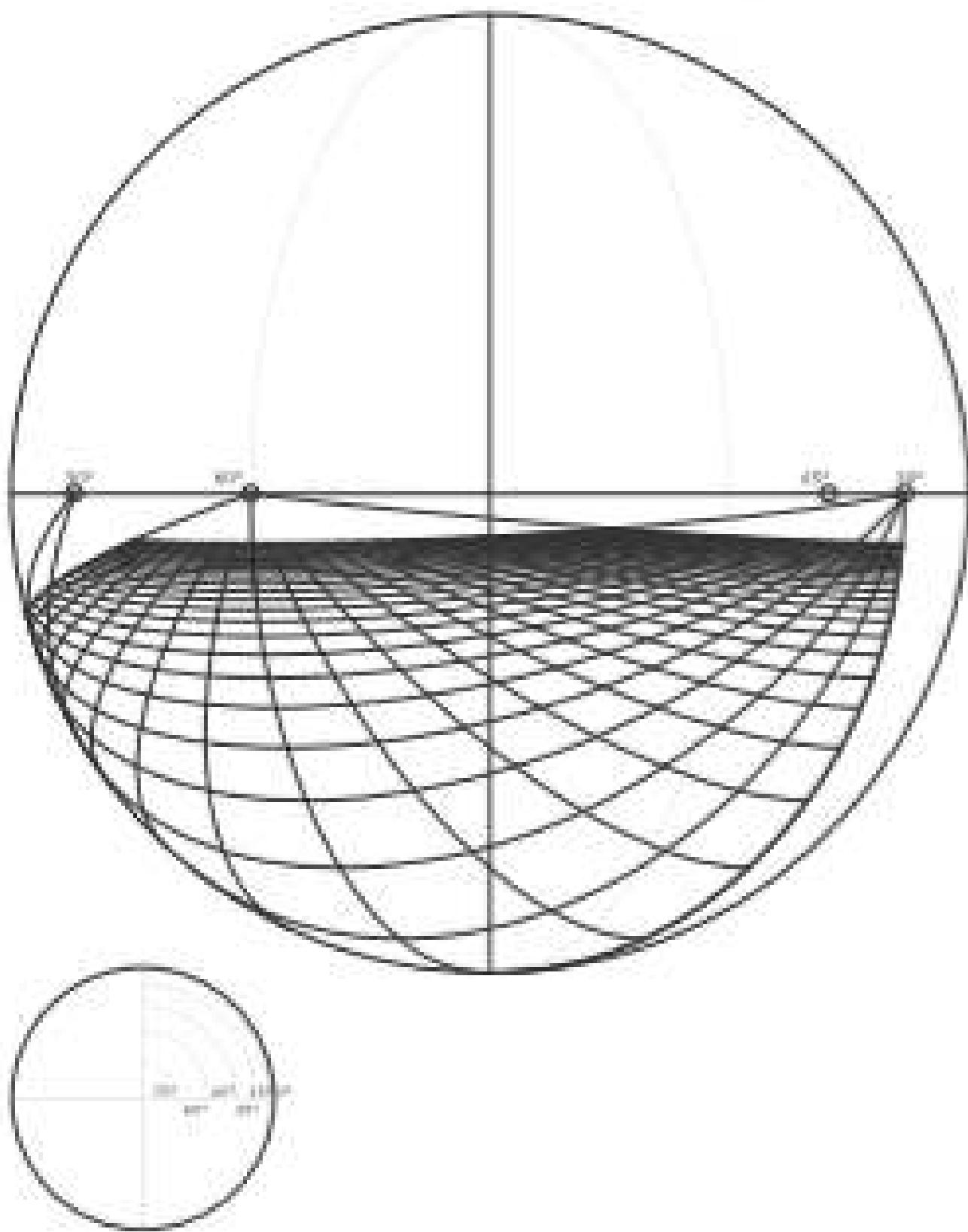
181 CURVILINEAR PERSPECTIVE

Perspective chart 60°



CURVILINEAR PERSPECTIVE

Perspective chart 30° / 60°



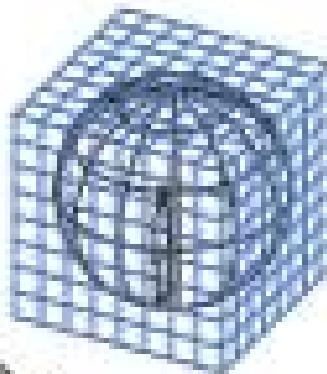
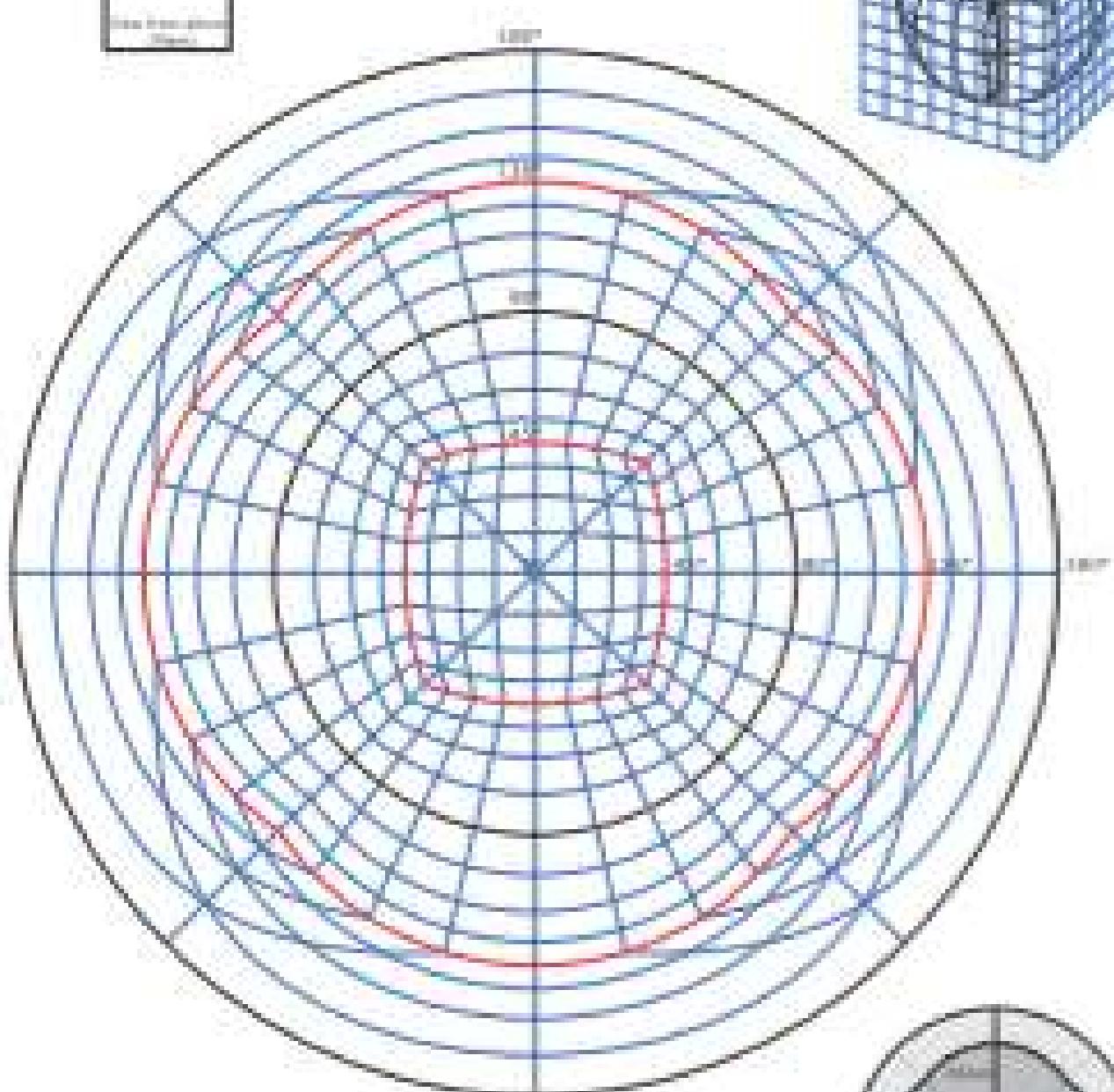
Behaviour and movement in the environment

IC1

CYLINDRICAL PERSPECTIVE

Projection of a cube on the spherical field of vision

Grid 30°

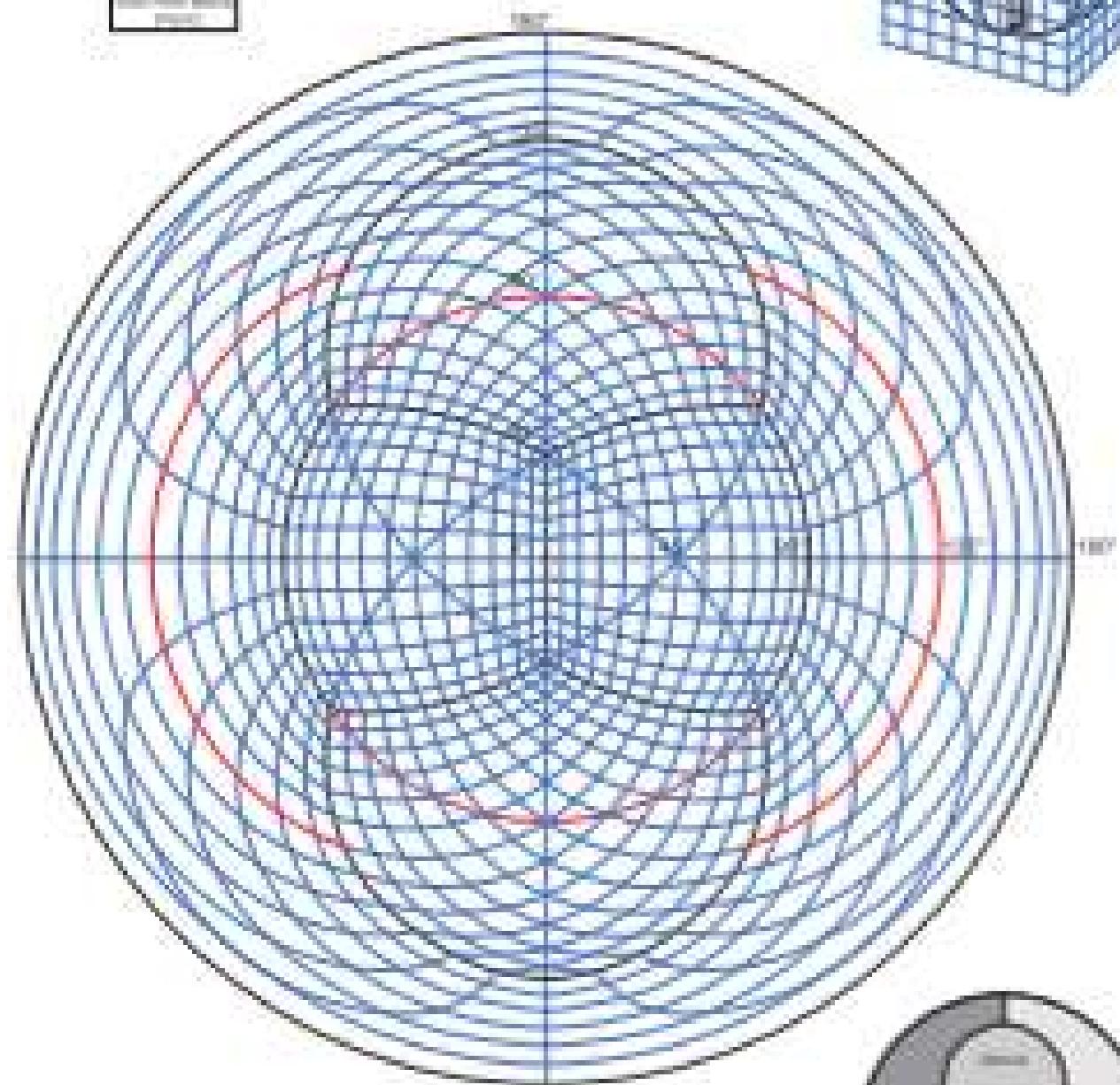
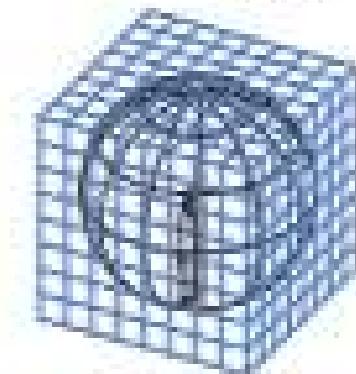




CURVILINEAR PERSPECTIVE

Projection of a cube on the spherical field of vision

Grid 45°



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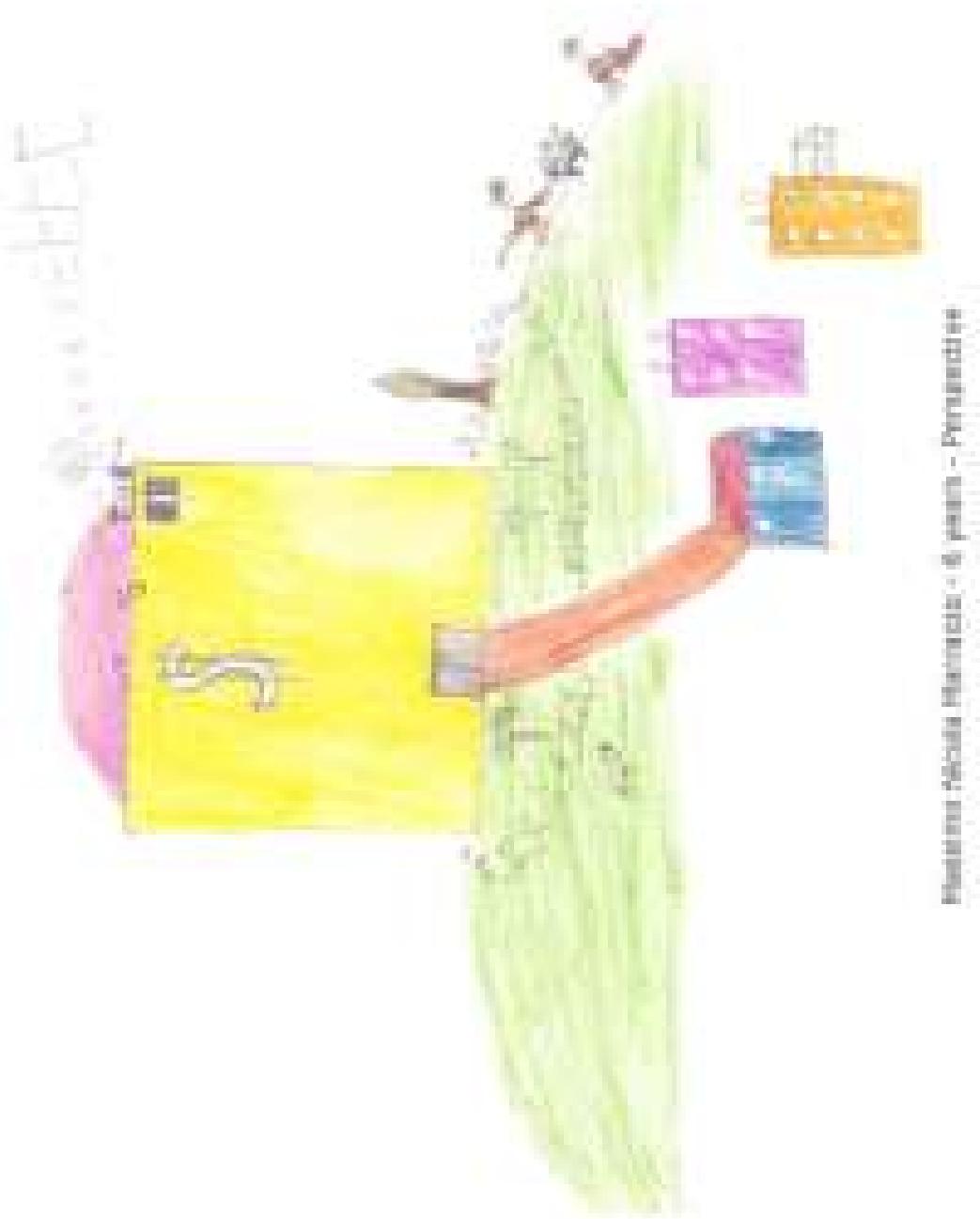
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Index



Yellow pencil

Red pencil - Blue and white checkered box - Pink flowers - Yellow box - Pencil case

