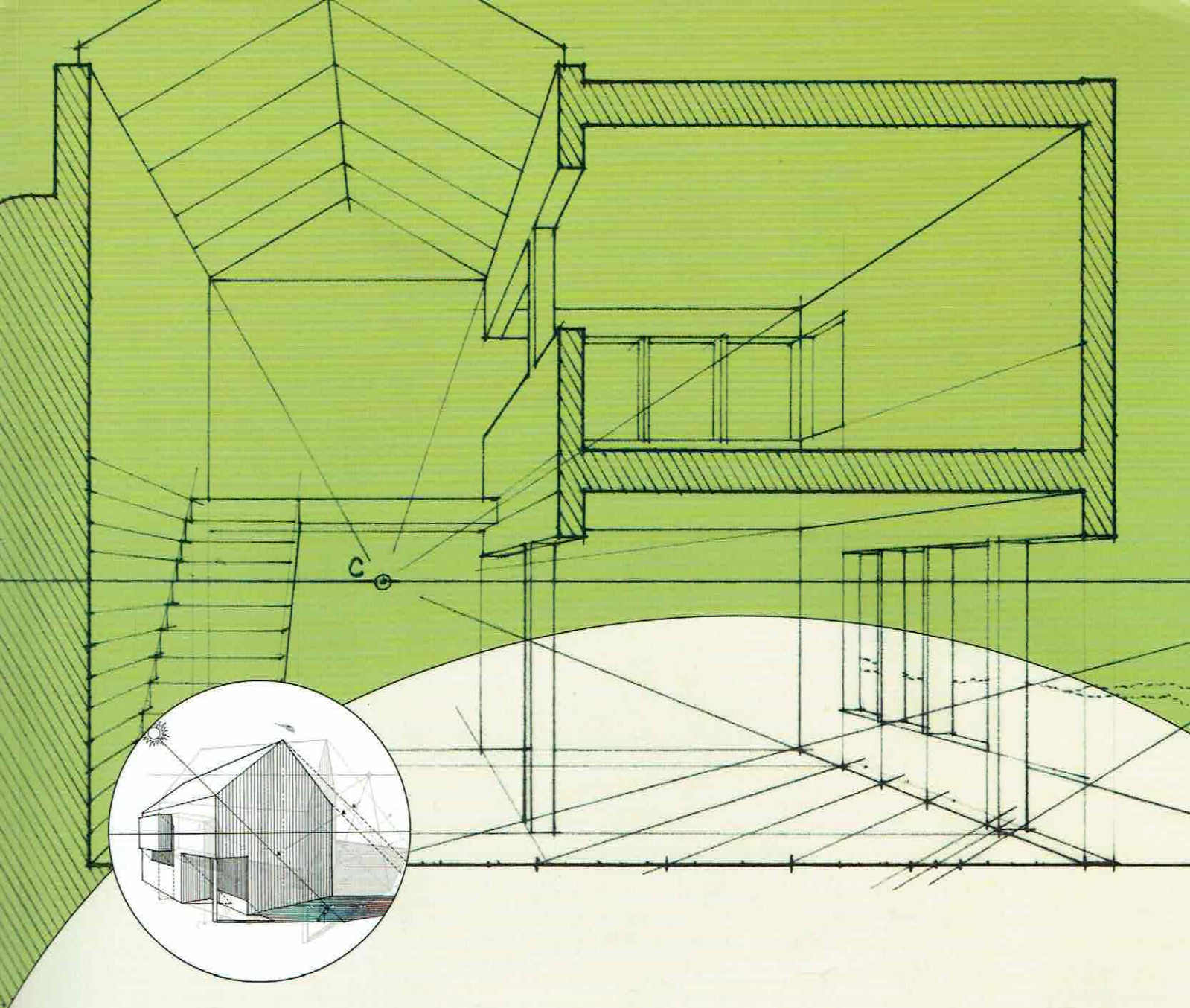




FOURTH EDITION

ARCHITECTURAL GRAPHICS

FRANCIS D.K. CHING

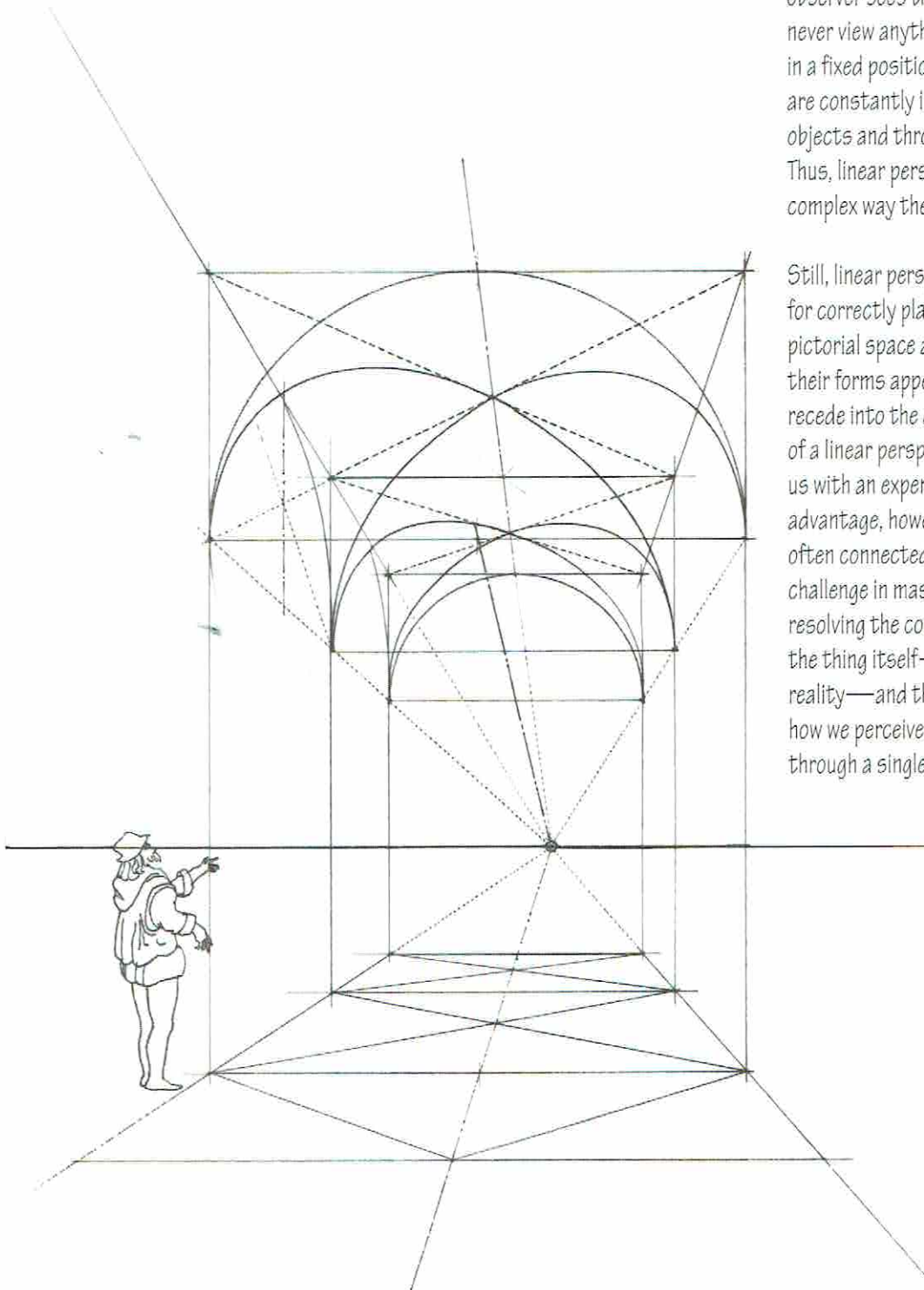
6

Perspective Drawings

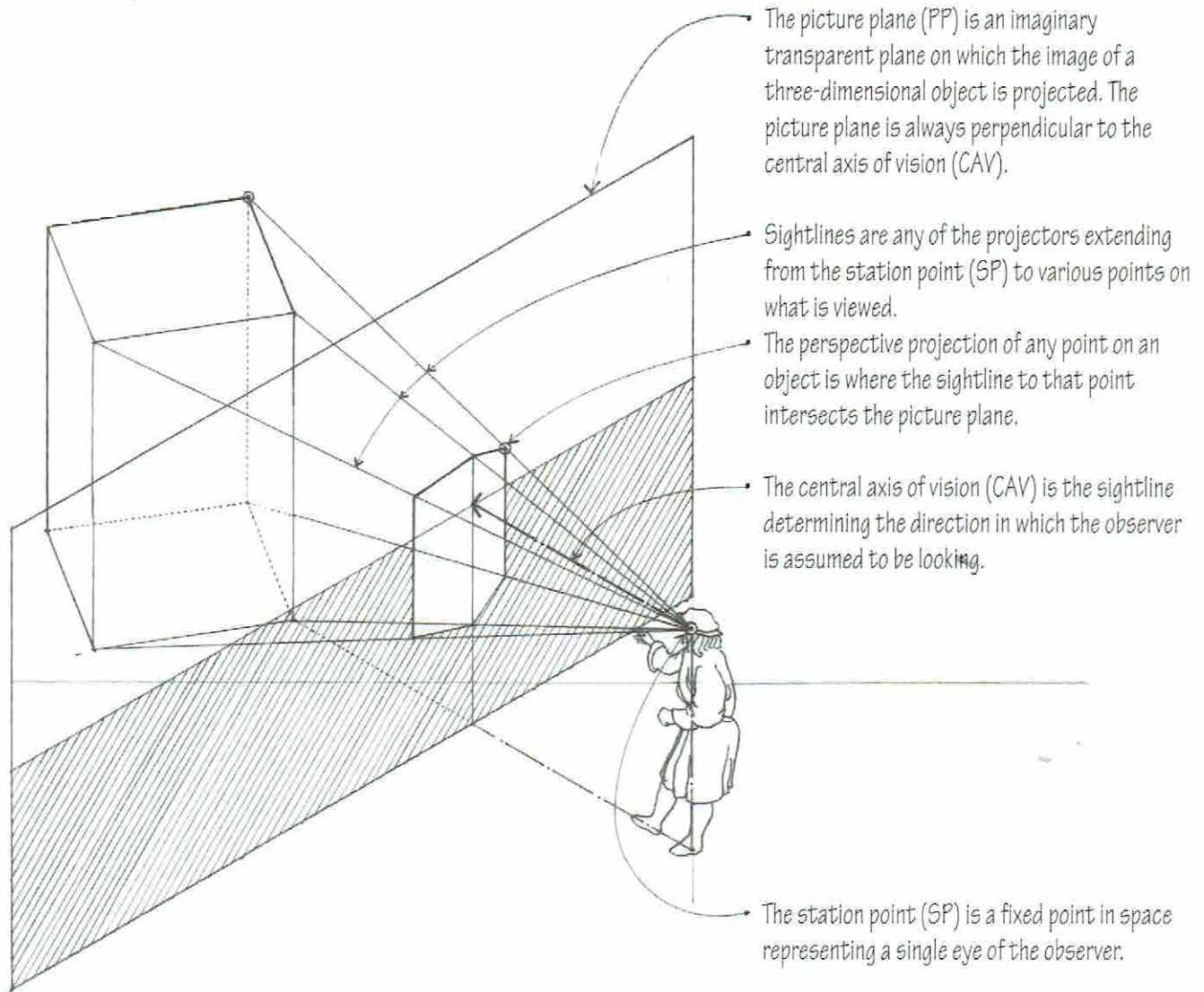
"Perspective" properly refers to any of various graphic techniques for depicting volumes and spatial relationships on a flat surface, such as size perspective and atmospheric perspective. The term "perspective," however, most often brings to mind the drawing system of linear perspective. Linear perspective is a technique for describing three-dimensional volumes and spatial relationships on a two-dimensional surface by means of lines that converge as they recede into the depth of a drawing. While multiview and paraline drawings present views of an objective reality, linear perspective offers scenes of an optical reality. It depicts how a construction or environment might appear to the eye of an observer looking in a specific direction from a particular vantage point in space.

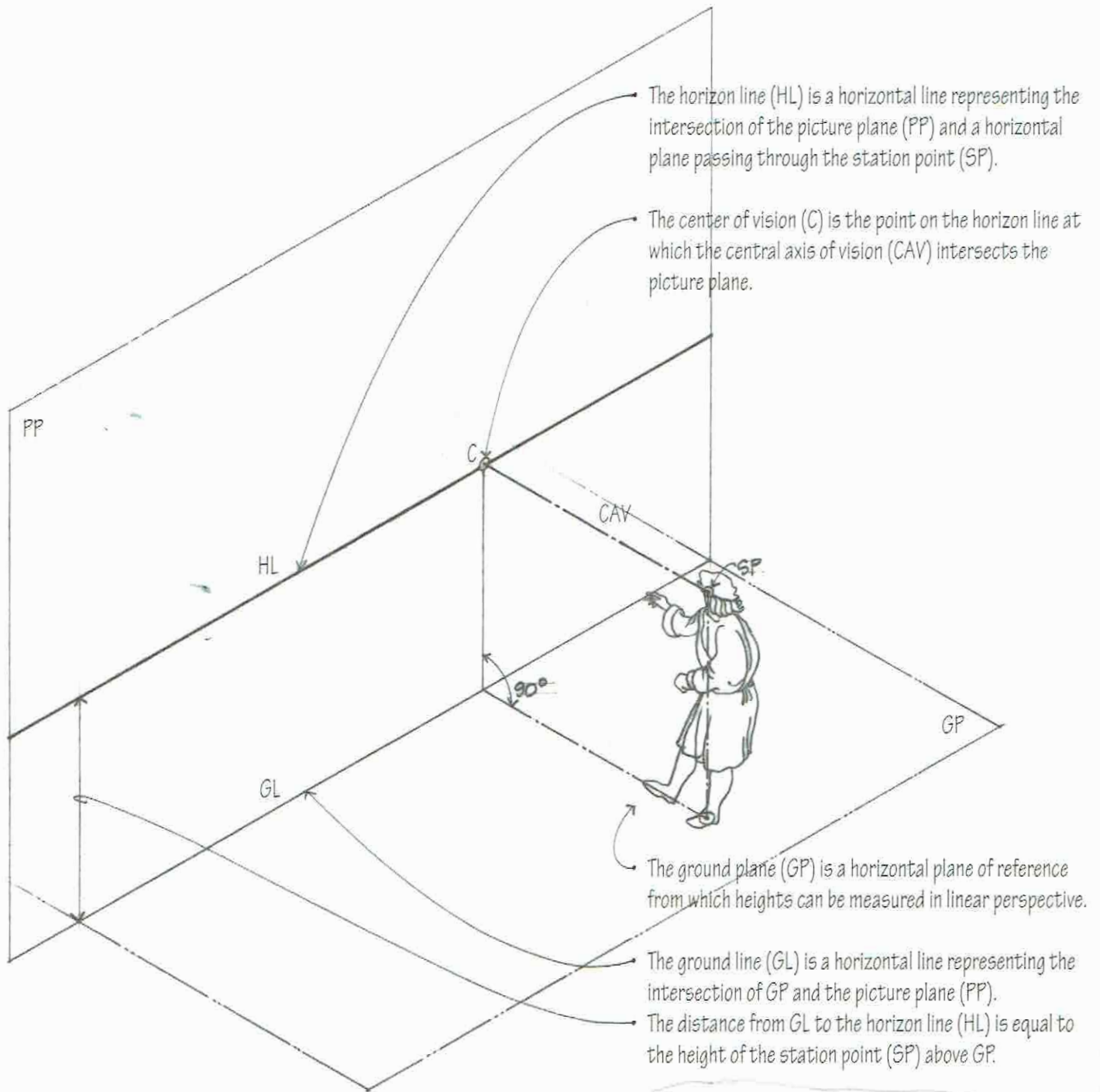
Linear perspective is valid only for monocular vision. A perspective drawing assumes that the observer sees through a single eye. We almost never view anything in this way. Even with the head in a fixed position, we see through both eyes, which are constantly in motion, roving over and around objects and through ever-changing environments. Thus, linear perspective can only approximate the complex way the eyes actually function.

Still, linear perspective provides us with a method for correctly placing three-dimensional objects in pictorial space and illustrating the degree to which their forms appear to diminish in size as they recede into the depth of a drawing. The uniqueness of a linear perspective lies in its ability to provide us with an experiential view of space. This distinct advantage, however, also gives rise to the difficulty often connected with perspective drawing. The challenge in mastering linear perspective is resolving the conflict between our knowledge of the thing itself—how we conceive its objective reality—and the appearance of something—how we perceive its optical reality—as seen through a single eye of the observer.



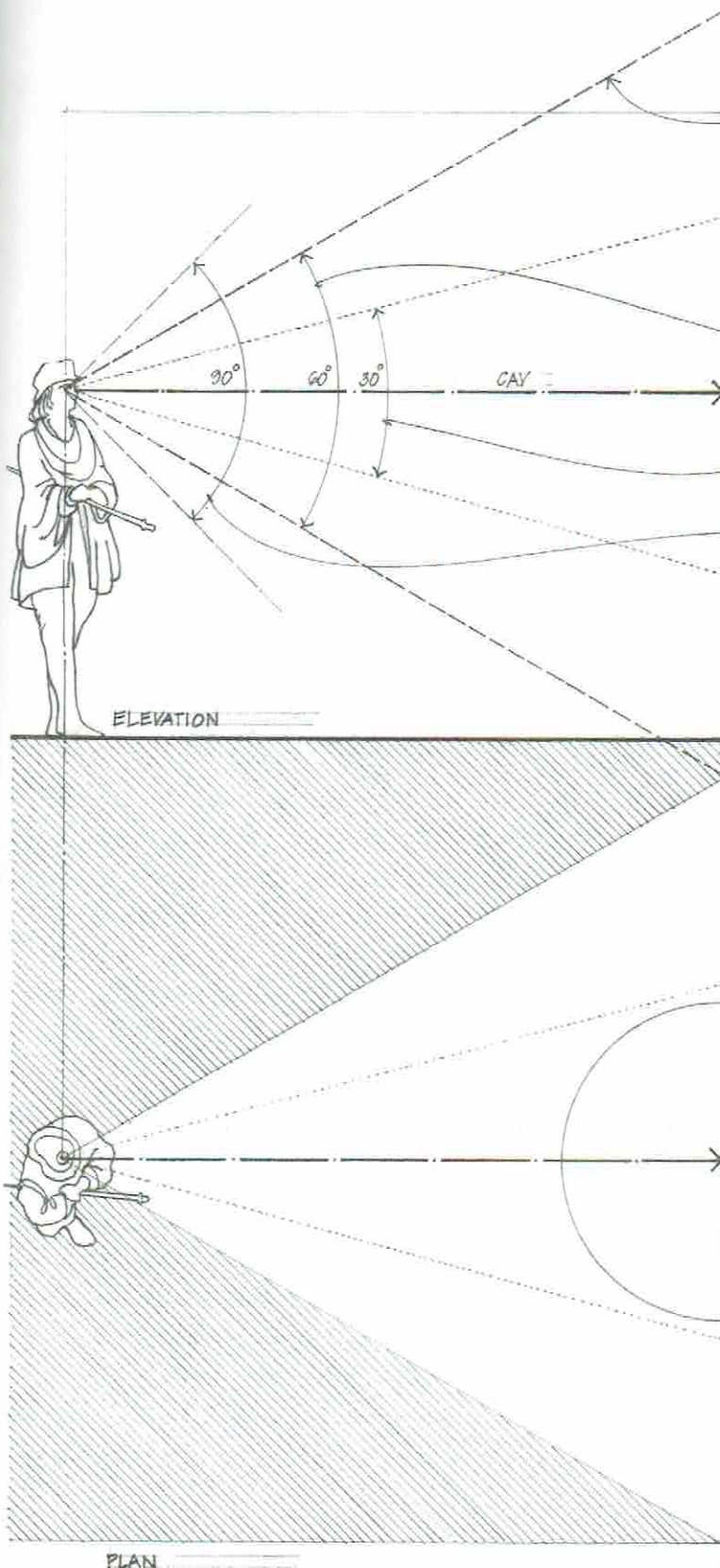
Perspective projection represents a three-dimensional object by projecting all its points to a picture plane by straight lines converging at a fixed point in space representing a single eye of the observer. This convergence of sightlines differentiates perspective projection from the other two major projection systems, orthographic projection and oblique projection, in which the projectors remain parallel to each other.





Digital Perspectives

3D CAD and modeling programs, while following the mathematical principles of perspective, can easily create distorted perspective views. Keeping the central portion of a subject or scene within a reasonable cone of vision is therefore critical to avoiding such distortion.



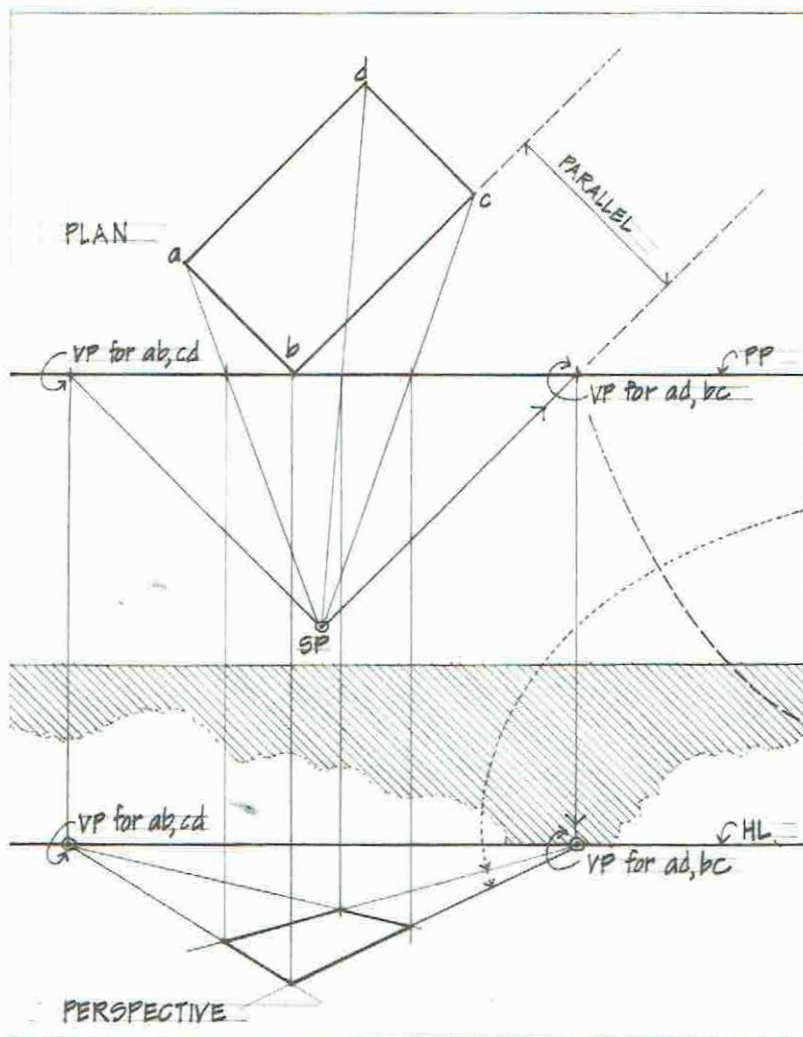
The cone of vision describes the sightlines radiating outward from SP and forming an angle with CAV in linear perspective. The cone of vision serves as a guide in determining what is to be included within the boundaries of a perspective drawing.

A 60° cone of vision is assumed to be the normal field of vision within which the principal aspects of the subject should be placed.

To minimize distortion of circles and circular shapes, they should fall within a 30° cone of vision.

A 90° cone of vision is acceptable for peripheral elements.

- Remember that the cone of vision is three-dimensional even though it is seen as a triangular shape in orthographic plans and elevations. Only a small portion of the immediate foreground falls within the cone of vision. As the cone of vision reaches out to gather in what the observer sees, it widens its field, and the middleground and background become more expansive.



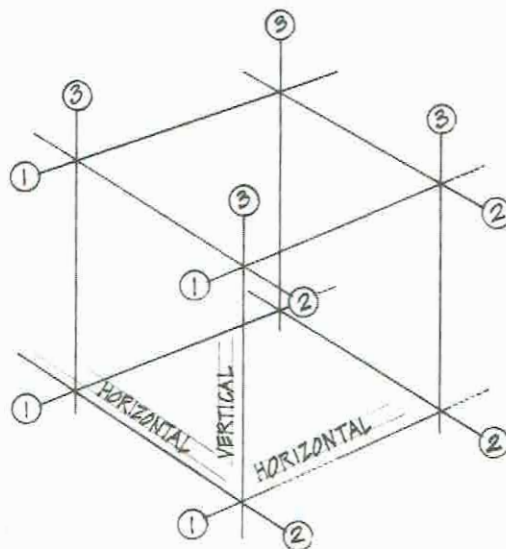
The converging nature of sightlines in linear perspective produces certain pictorial effects. Being familiar with these pictorial effects helps us understand how lines, planes, and volumes should appear in linear perspective and how to place objects correctly in the space of a perspective drawing.

Convergence

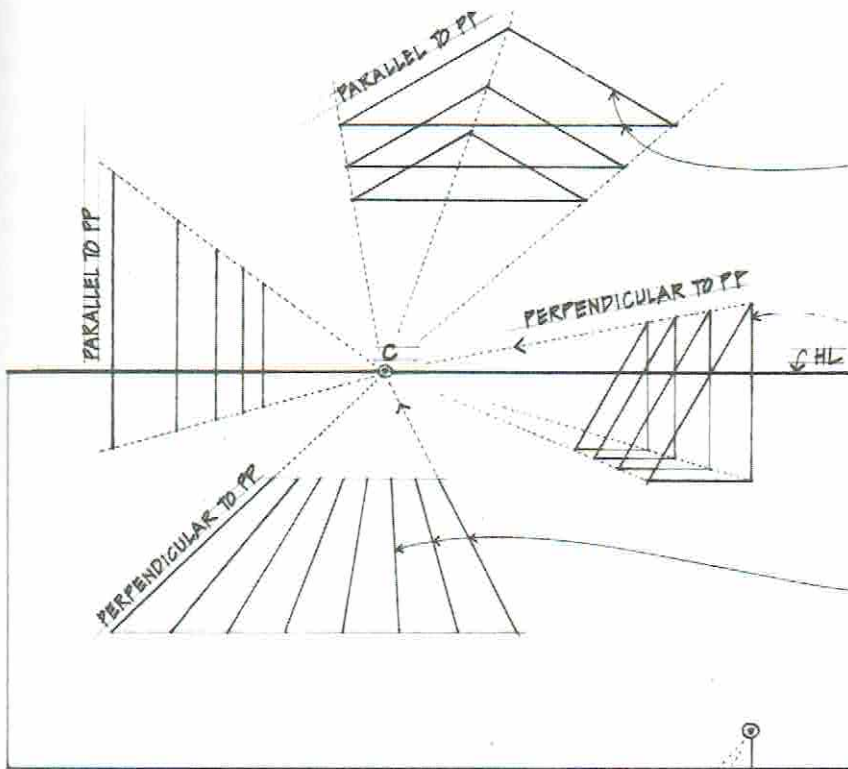
Convergence in linear perspective refers to the apparent movement of parallel lines toward a common vanishing point as they recede.

- As two parallel lines recede into the distance, the space between them will appear to diminish. If the lines are extended to infinity, they will appear to meet at a point on the picture plane (PP). This point is the vanishing point (VP) for that particular pair of lines and all other lines parallel to them.
- The vanishing point (VP) for any set of parallel lines is the point where a line drawn from the station point (SP) parallel to the set intersects PP.

The first rule of convergence is that each set of parallel lines has its own vanishing point. A set of parallel lines consists only of those lines that are parallel to one another. If we look at a cube, for example, we can see that its edges comprise three principal sets of parallel lines, one set of vertical lines parallel to the X-axis, and two sets of horizontal lines, perpendicular to each other and parallel to the Y- and Z-axes.



In order to draw a perspective, we must know how many sets of parallel lines exist in what we see or envision and where each set will appear to converge. The following guidelines for the convergence of parallel lines is based solely on the relationship between the observer's central axis of vision and the subject.



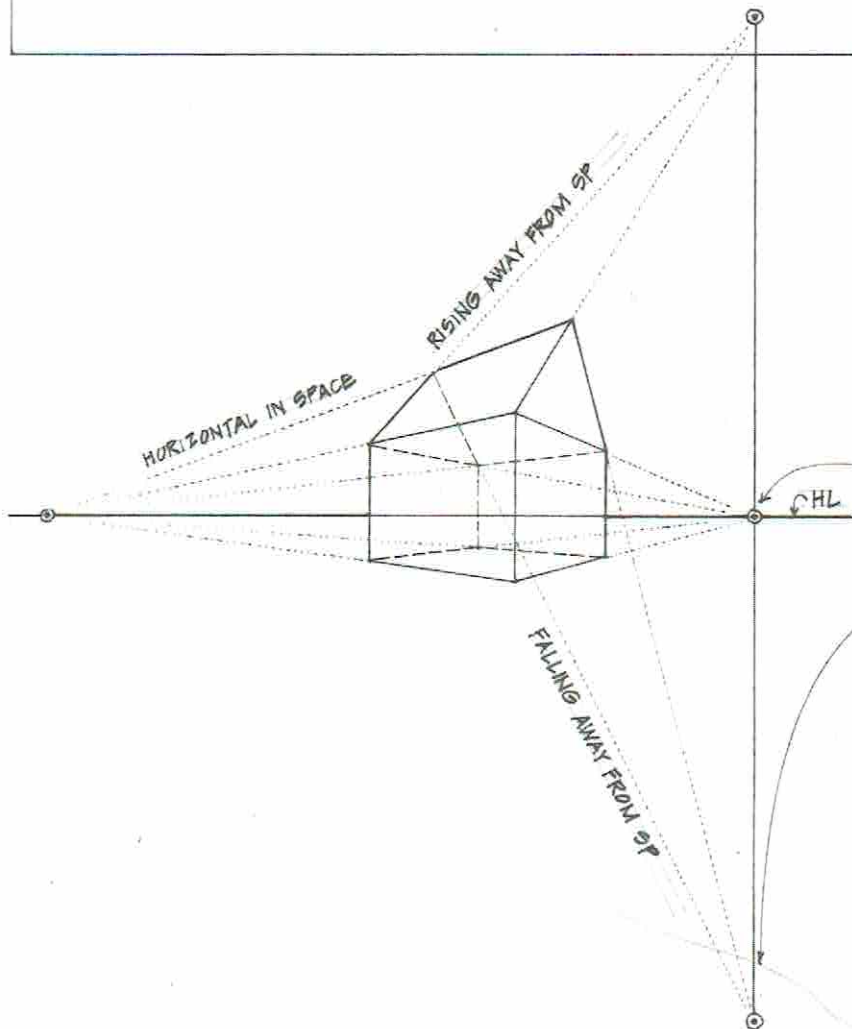
Lines Parallel to the Picture Plane

If parallel with the picture plane (PP), a set of parallel lines will retain its orientation and not converge to a vanishing point. Each line in the set, however, will diminish in size according to its distance from the observer.

In a similar manner, shapes parallel with PP will retain their form but diminish in size according to their distance from the observer.

Lines Perpendicular to the Picture Plane

If perpendicular to the picture plane (PP), a set of parallel lines will appear to converge on the horizon line (HL) at the center of vision (C).

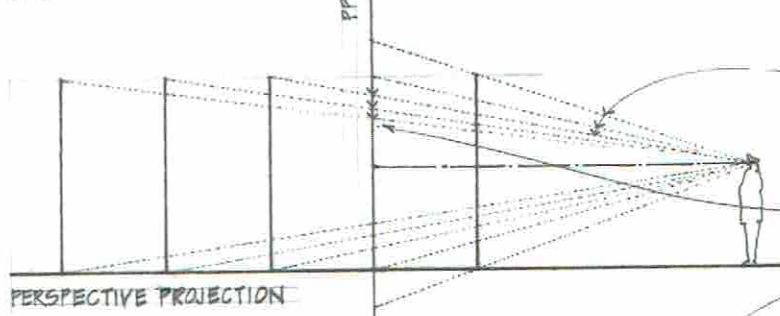
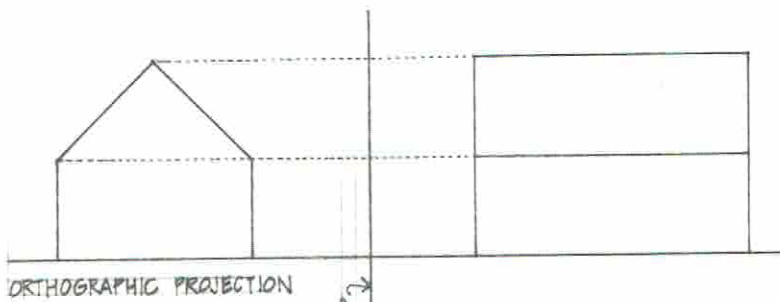


Lines Oblique to the Picture Plane

If oblique to the picture plane (PP), a set of parallel lines will appear to converge toward a common vanishing point as it recedes.

If a horizontal set of parallel lines is oblique to PP, its vanishing point will always lie somewhere on the horizon line (HL).

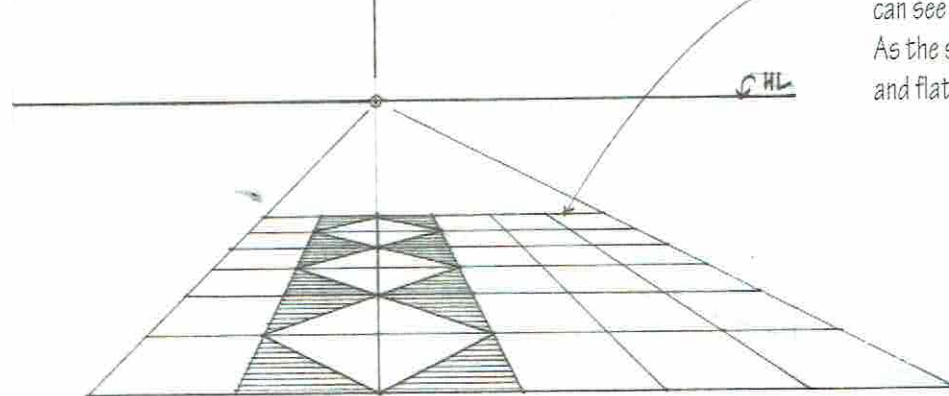
If a set of parallel lines rises upward as it recedes, its vanishing point lies above HL. If it slopes downward as it recedes, its vanishing point lies below HL.



Diminution of Size

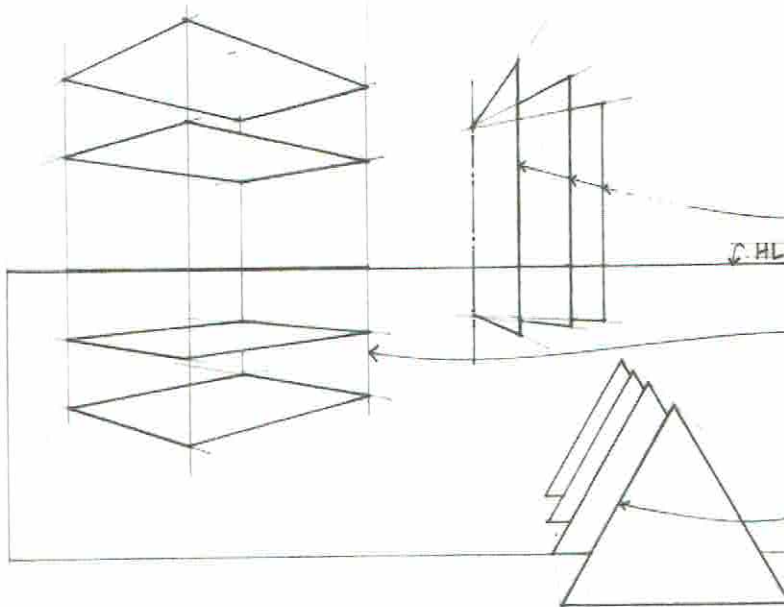
In orthographic and oblique projection, the projectors remain parallel to each other. Therefore, the projected size of an element remains the same regardless of its distance from the picture plane. In linear perspective, however, the converging projectors or sightlines alter the apparent size of a line or plane according to its distance from the picture plane.

- Converging sightlines reduce the size of distant objects, making them appear smaller than identical objects closer to the picture plane (PP).
- Note also that as an object recedes, sightlines to the object approach the horizon line (HL).
- For example, looking down on a tiled floor pattern, we can see more of the tiles' surfaces in the foreground. As the same-size tiles recede, they appear smaller and flatter as they rise and approach the horizon.



Other Pictorial Effects

Perspective drawings also possess other pictorial characteristics found in multiview and paraline drawing systems.



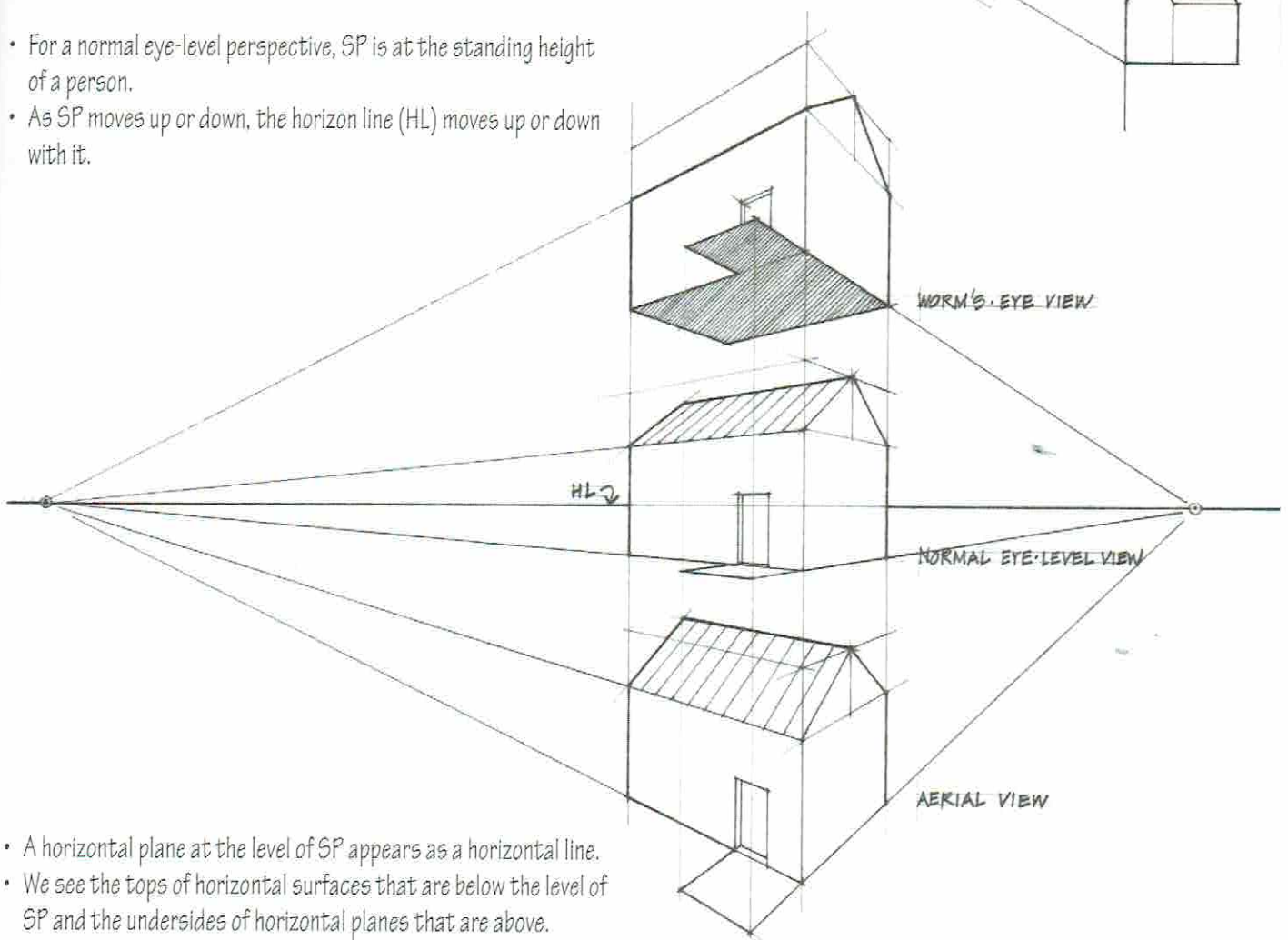
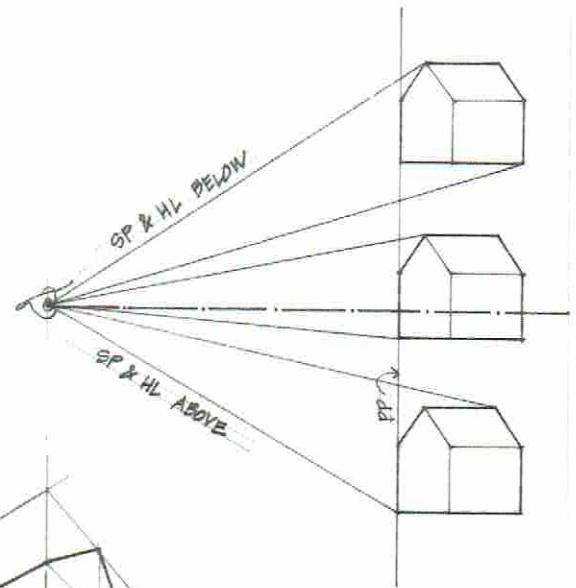
- Foreshortening refers to the apparent compression in size or length when a facet of an object rotates away from the picture plane (PP).
- In linear perspective, foreshortening also results when a facet of an object perpendicular or oblique to PP moves laterally or vertically with respect to the central axis of vision (CAV).
- In all drawing systems, the overlapping of shapes and forms is an essential visual cue to spatial depth.

The observer's point of view determines the pictorial effect of a perspective drawing. As this viewpoint changes—as the observer moves up or down, to the left or right, forward or back—the extent and emphasis of what the observer sees also changes. In order to achieve the desired view in perspective, we should understand how to adjust the following variables.

Height of the Station Point

The height of the station point (SP) relative to an object determines whether it is seen from above, below, or within its own height.

- For a normal eye-level perspective, SP is at the standing height of a person.
- As SP moves up or down, the horizon line (HL) moves up or down with it.



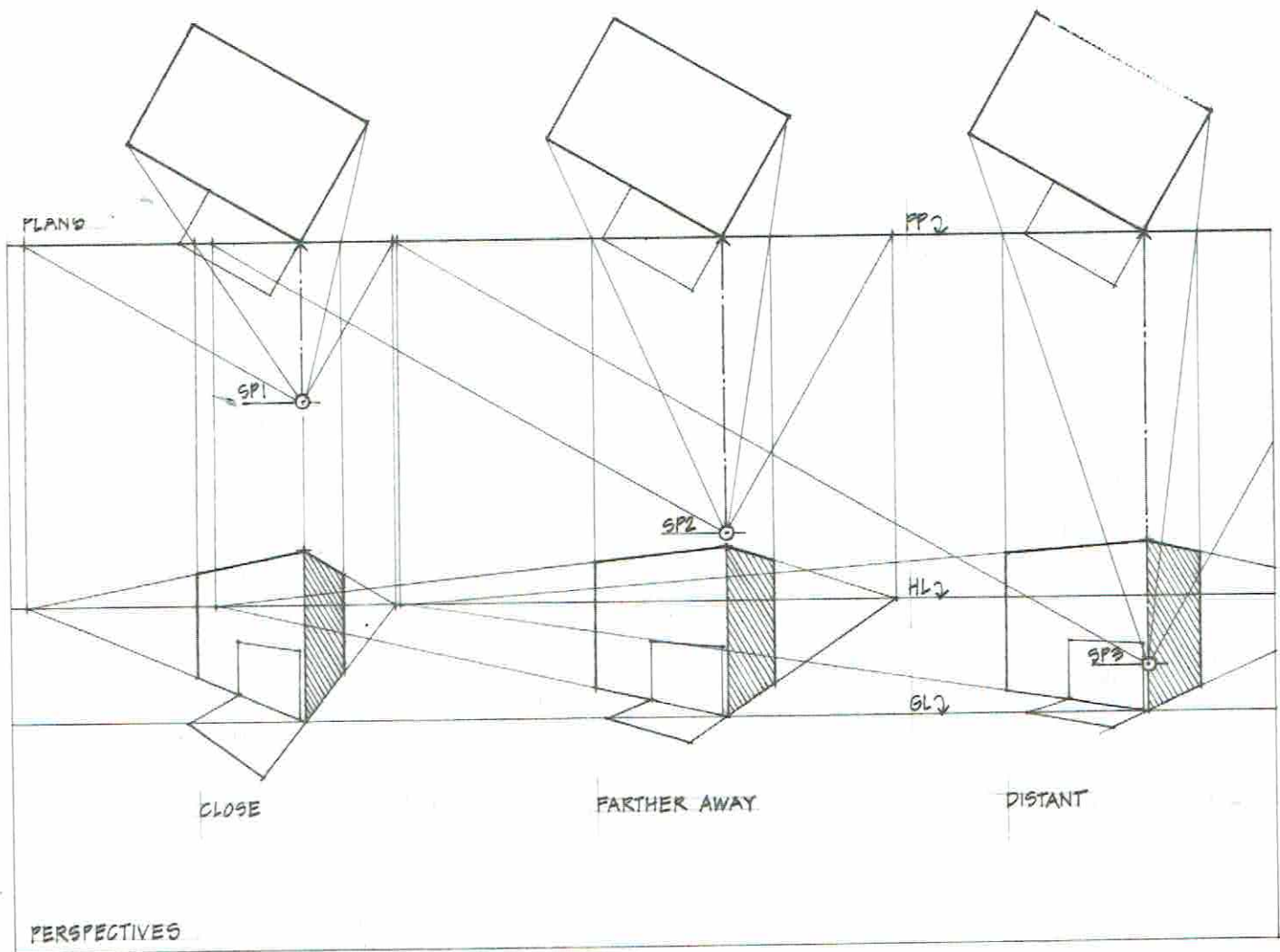
- A horizontal plane at the level of SP appears as a horizontal line.
- We see the tops of horizontal surfaces that are below the level of SP and the undersides of horizontal planes that are above.

- Even if not actually visible in a perspective view, the horizon line should always be drawn lightly across the drawing surface to serve as a level line of reference for the entire composition.

PERSPECTIVE VARIABLES

Distance of the Station Point to the Object

The distance of the station point (SP) to an object influences the rate of foreshortening of the object's surfaces that occurs in the perspective drawing.



- As the observer's SP moves farther away from the object, the vanishing points for the object move farther apart, horizontal lines flatten out, and perspective depth is compressed.

- As the observer's SP moves forward, the vanishing points for the object move closer together, horizontal angles become more acute, and perspective depth is exaggerated.

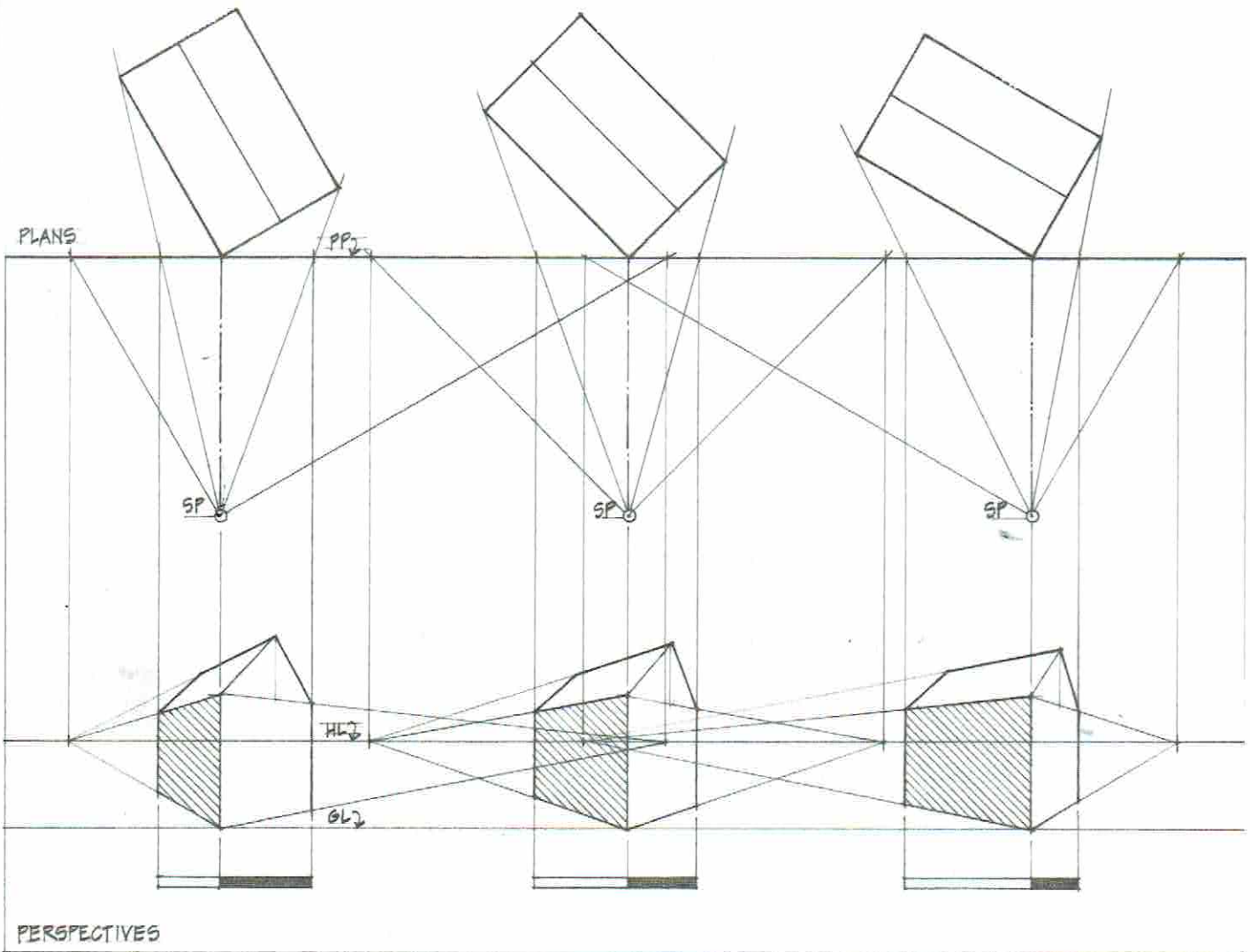
- In theory, a perspective drawing presents a true picture of an object only when the eye of the viewer is located at the assumed station point (SP) of the perspective.

Angle of View

The orientation of the central axis of vision (CAV) and the picture plane (PP) relative to an object determines which faces of the object are visible and the degree to which they are foreshortened in perspective.

Digital Viewpoints

In constructing a perspective by hand, we must have experience in setting up the station point and the angle of view to predict and achieve a reasonable outcome. A distinct advantage in using 3D CAD and modeling programs is that once the necessary data is entered for a three-dimensional construction, the software allows us to manipulate the perspective variables and fairly quickly produce a number of perspective views for evaluation. Judgment of what a perspective image conveys, whether produced by hand or with the aid of the computer, remains the responsibility of its author.



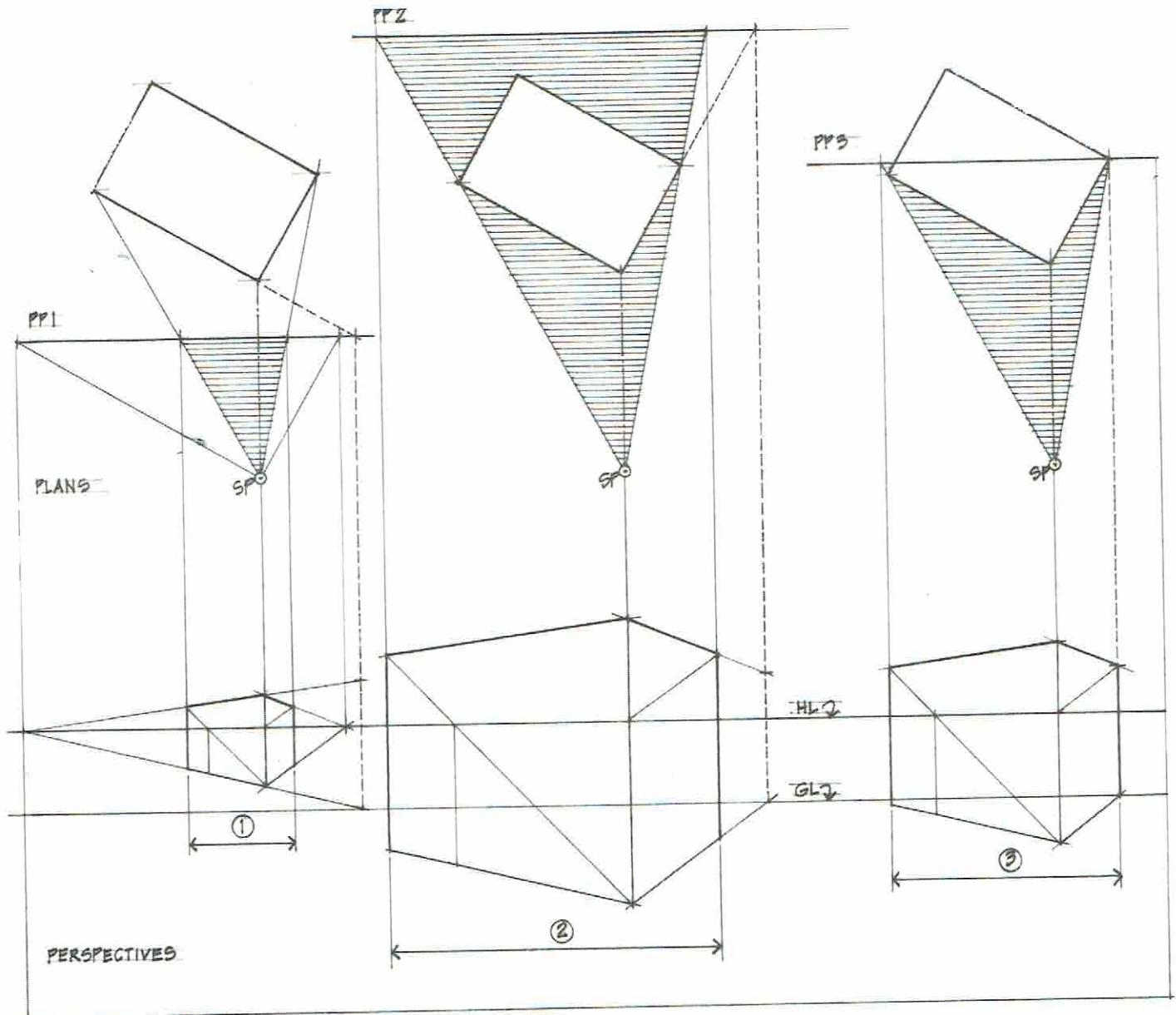
- The more a plane is rotated away from PP, the more it is foreshortened in perspective.

- The more frontal the plane is, the less it is foreshortened.
- When a plane becomes parallel to PP, its true shape is revealed.

PERSPECTIVE VARIABLES

Location of the Picture Plane

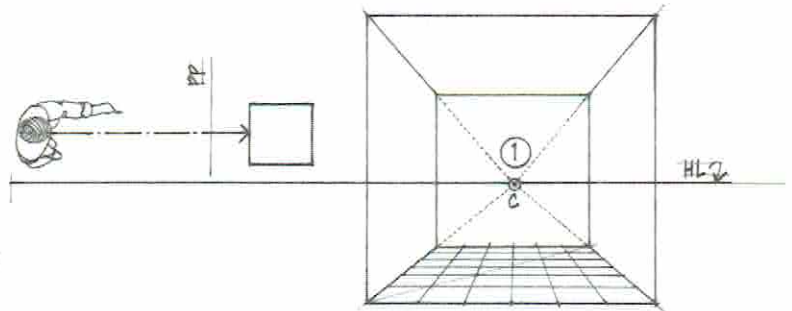
The location of the picture plane (PP) relative to an object affects only the final size of the perspective image. The closer PP is to the station point (SP), the smaller the perspective image. The farther away PP is, the larger the image. Assuming all other variables remain constant, the perspective images are identical in all respects except size.



In any rectilinear object, such as a cube, each of the three principal sets of parallel lines has its own vanishing point. Based on these three major sets of lines, there are three types of linear perspective: one-, two-, and three-point perspectives. What distinguishes each type is simply the observer's angle of view relative to the subject. The subject does not change, only our view of it, but the change of view affects how the sets of parallel lines appear to converge in linear perspective.

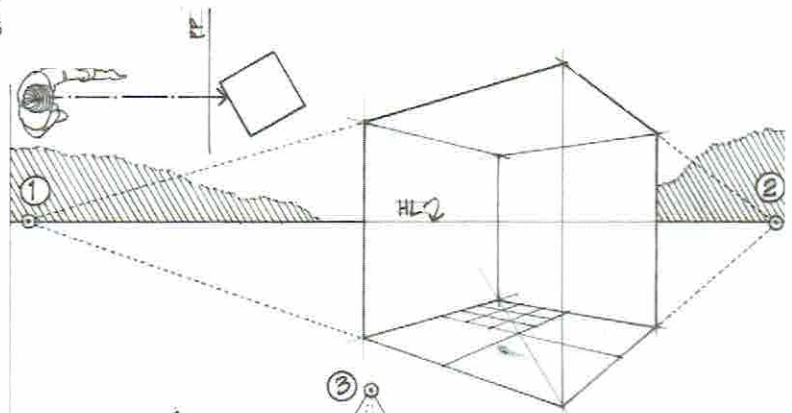
One-Point Perspective

If we view a cube with our central axis of vision (CAV) perpendicular to one of its faces, all of the cube's vertical lines are parallel with the picture plane (PP) and remain vertical. The horizontal lines that are parallel with PP and perpendicular to CAV also remain horizontal. The lines that are parallel with CAV, however, will appear to converge at the center of vision (C). This is the one point referred to in one-point perspective.



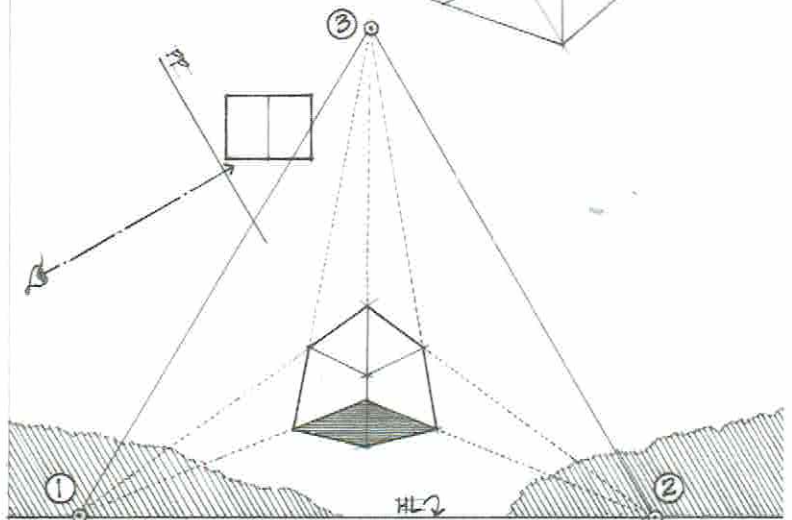
Two-Point Perspective

If we shift our point of view so that we view the same cube obliquely, but keep our central axis of vision (CAV) horizontal, then the cube's vertical lines will remain vertical. The two sets of horizontal lines, however, are now oblique to the picture plane (PP) and will appear to converge, one set to the left and the other to the right. These are the two points referred to in two-point perspective.

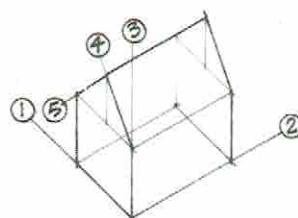


Three-Point Perspective

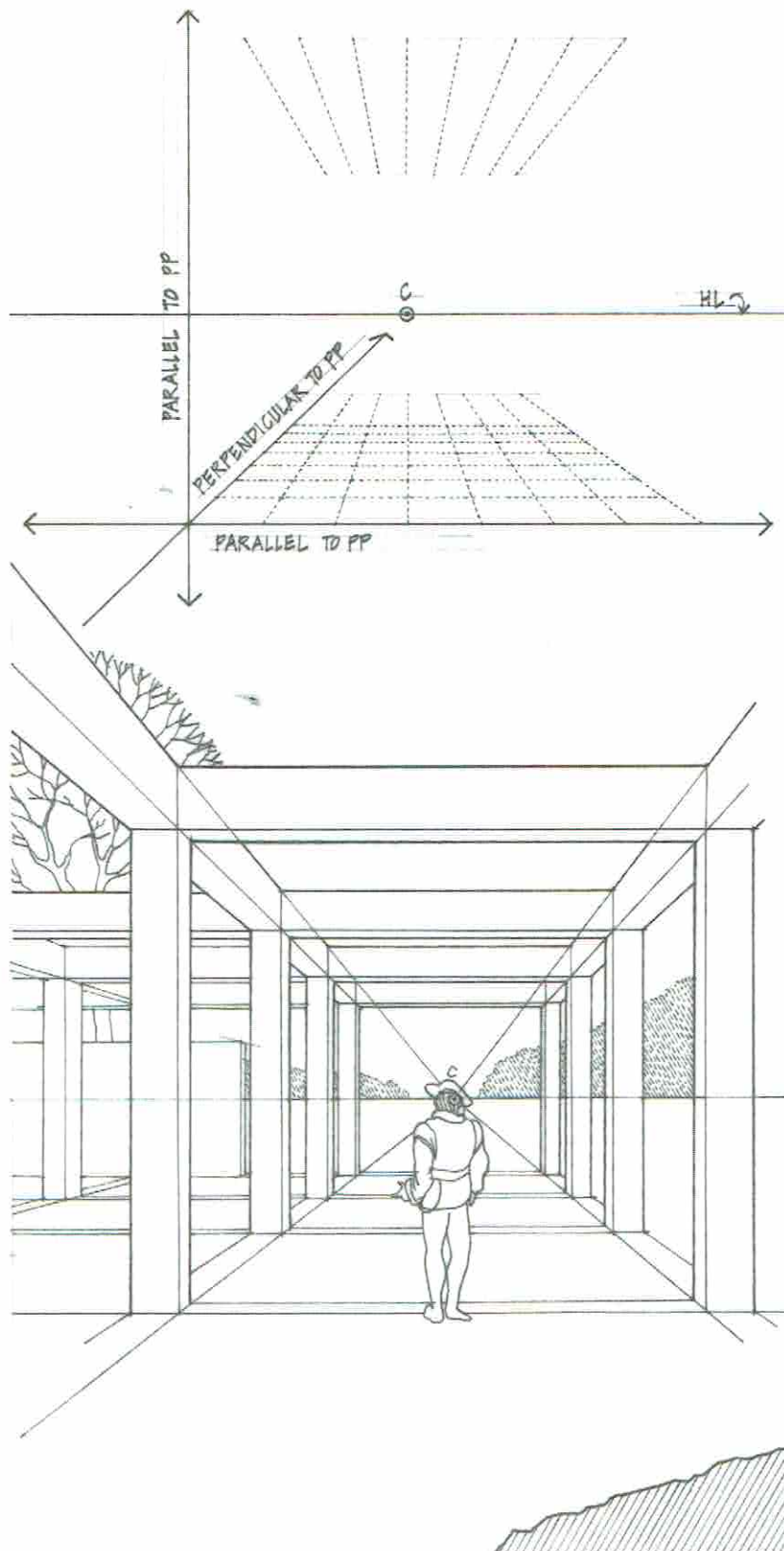
If we lift one corner of the cube off the ground plane (GP), or if we tilt our central axis of vision (CAV) to look down or up at the cube, then all three sets of parallel lines will be oblique to the picture plane (PP) and will appear to converge at three different vanishing points. These are the three points referred to in three-point perspective.



Note that each type of perspective does not imply that there are only one, two, or three vanishing points in a perspective. The actual number of vanishing points will depend on our point of view and how many sets of parallel lines there are in the subject being viewed. For example, if we look at a simple gable-roofed form, we can see that there are potentially five vanishing points, since we have one set of vertical lines, two sets of horizontal lines, and two sets of inclined lines.



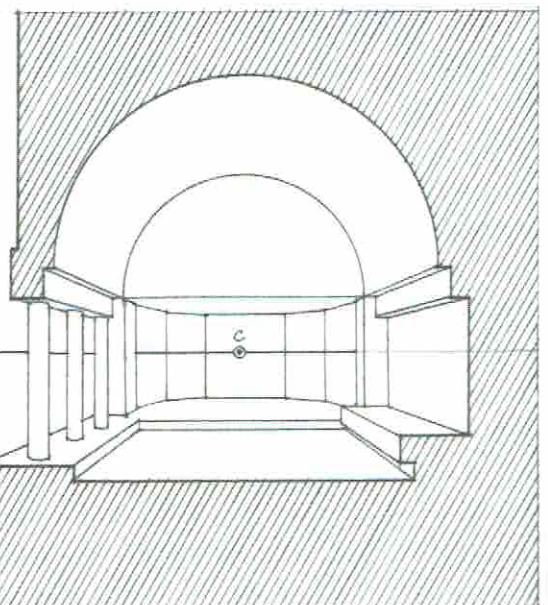
ONE-POINT PERSPECTIVE



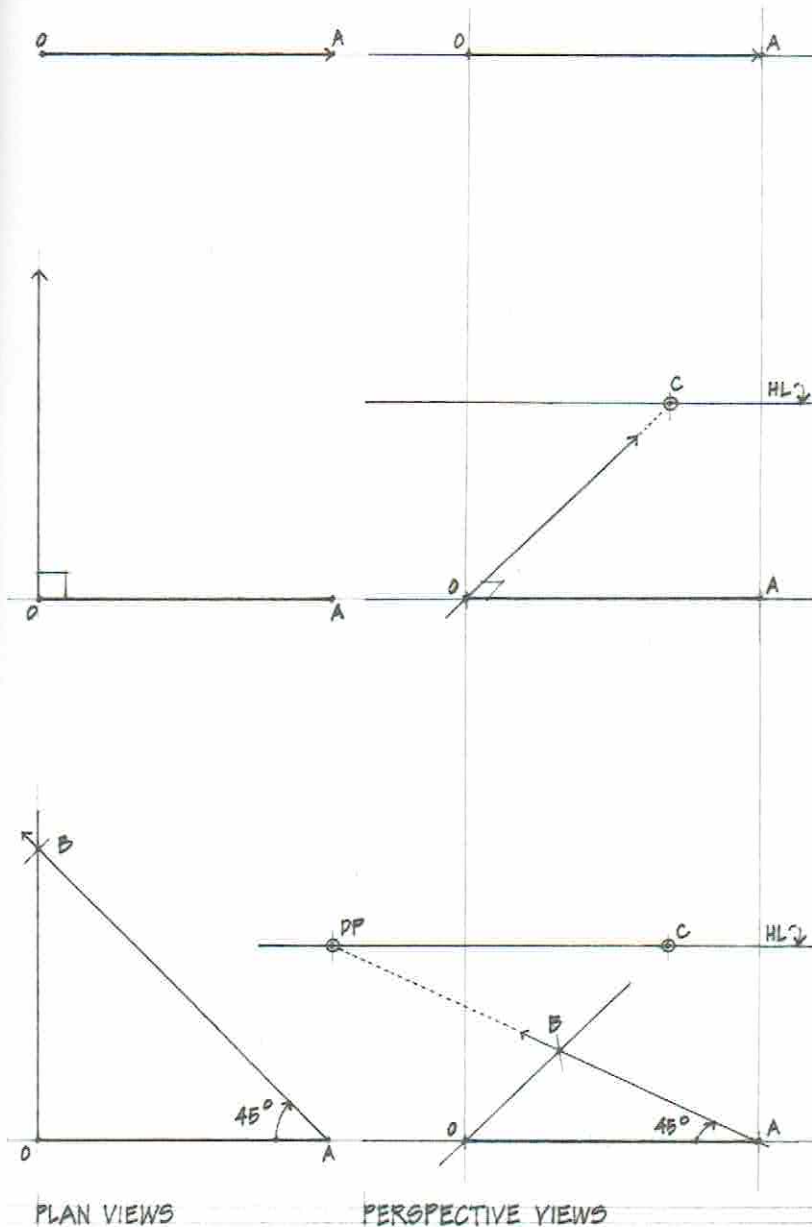
The one-point perspective system assumes that two of the three principal axes—one vertical and the other horizontal—are parallel to the picture plane. All lines parallel to these axes are also parallel to the picture plane (PP), and therefore retain their true orientation and do not appear to converge. For this reason, one-point perspective is also known as parallel perspective.

The third principal axis is horizontal, perpendicular to PP and parallel with the central axis of vision (CAV). All lines parallel to CAV converge on the horizon line (HL) at the center of vision (C). This is the particular vanishing point referred to in one-point perspective.

The one-point perspective system is particularly effective in depicting the interior of a spatial volume because the display of five bounding faces provides a clear sense of enclosure. For this reason, designers often use one-point perspectives to present experiential views of street scenes, formal gardens, courtyards, colonnades, and interior rooms. We can also use the presence of the central vanishing point to focus the viewer's attention and emphasize axial and symmetrical arrangements in space.



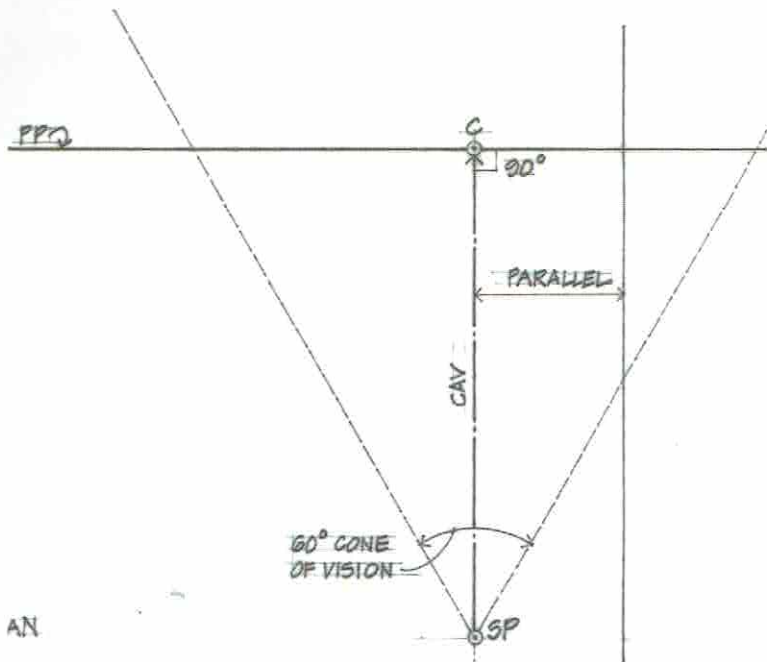
The diagonal point method for constructing a one-point perspective uses the geometry of a 45° right triangle and the principles of convergence to make depth measurements in perspective.



- The technique involves establishing one side of a 45° right triangle in or parallel to the picture plane (PP) so that we can use it as a measuring line (ML). Along this side (OA), we measure a length equal to the desired perspective depth.
- Through endpoint O of this length, we draw the perpendicular side that converges at the center of vision (C).
- From the other endpoint A, we draw the hypotenuse that converges at the vanishing point for lines making a 45° angle with the picture plane (PP).
- This diagonal marks off a perspective depth (OB) that is equal to length OA.

One-Point Perspective Grid

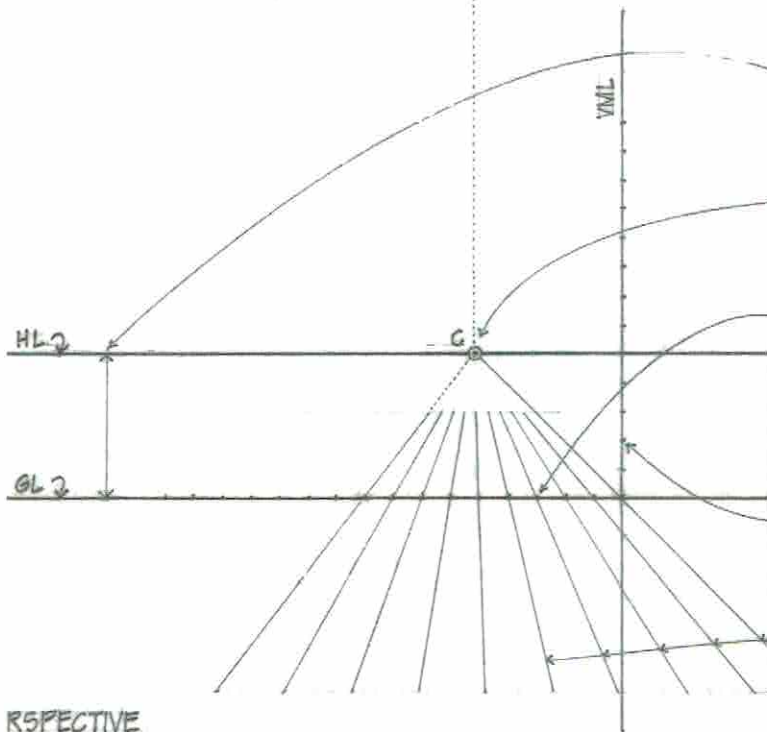
We can use the diagonal point method to construct a one-point perspective grid easily. A perspective grid is a perspective view of a three-dimensional coordinate system. The three-dimensional network of uniformly spaced points and lines enables us to correctly establish the form and dimensions of an interior or exterior space, as well to regulate the position and size of objects within the space.



Plan Setup

- Before beginning the construction of any perspective, we should first determine the desired point of view: What do we wish to illustrate in the perspective view and why?
- After we determine the space we are going to illustrate, we next establish the station point (SP) and the central axis of vision (CAV) in the plan view.
- Because this is a one-point perspective, CAV should be parallel to one major axis of the space and perpendicular to the other.
- We locate SP within the space but far enough back that the majority of the space lies within a 60° cone of vision.
- SP and CAV should be located off-center to avoid constructing a static, symmetrical perspective image.
- For ease of construction, we can locate PP coincidental with a major plane perpendicular to CAV.

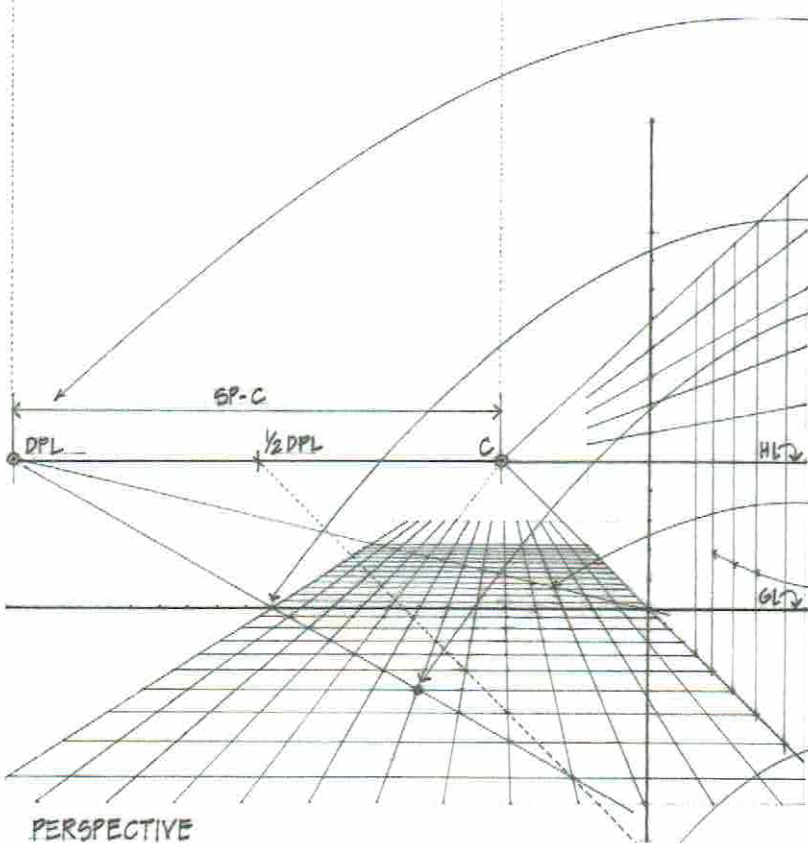
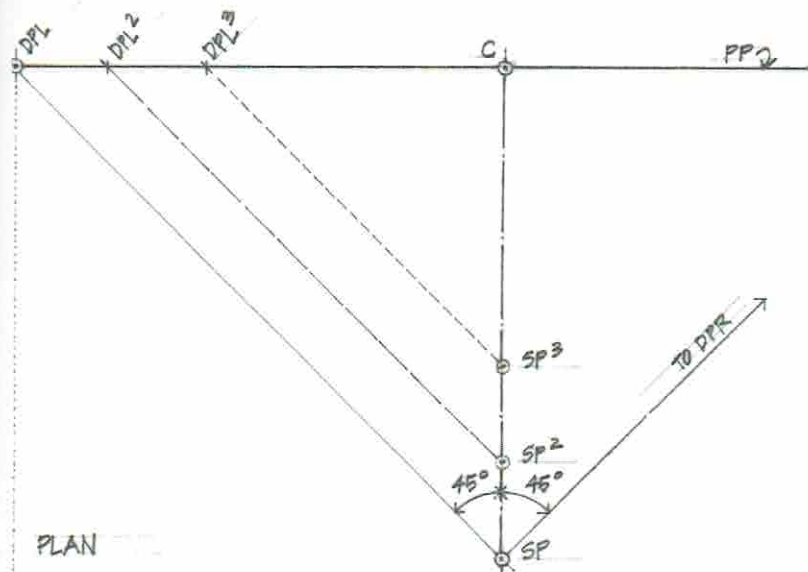
Constructing the Perspective Grid



- We start by deciding on a scale for the picture plane (PP), taking into consideration both the dimensions of the space and the desired size of the perspective drawing. PP need not be drawn at the same scale as the plan setup.
- At the scale of PP, we establish the ground line (GL) and the horizon line (HL) at the height of the eye level of the observer, that is, the station point (SP) above the ground plane (GP).
- We establish the center of vision (C) on HL. The position of C can be determined from the plan setup.
- Along GL, we lay out to scale equal increments of measurement. The unit of measurement is typically one foot; we can, however, use smaller or larger increments depending on the scale of the drawing and the amount of detail desired in the perspective view.
- We do the same along a vertical measuring line (VML) drawn through one of the measured points at one end of GL.
- Through each of the measured points on GL, we draw receding lines that are perpendicular to PP and therefore converge at C.

Diagonal Points

- If we draw a 45° line from the station point (SP) in a plan view of the perspective setup, it will intersect the picture plane (PP) at the vanishing point for that diagonal and all lines parallel to it. We call this vanishing point a diagonal point (DP).
- There is one DP for horizontal diagonal lines receding to the left (DPL), and another for horizontal diagonal lines receding to the right (DPR).
- Both diagonal points lie on the horizon line (HL), equidistant from the center of vision (C). From the geometry of the 45° right triangle, we know that the distance from each DP to C is equal to the distance from SP to C in the plan setup.
- Note that if we move each DP toward C, this is equivalent to the observer moving closer to PP. If we shift each DP farther away from C, the observer also moves farther away from PP.

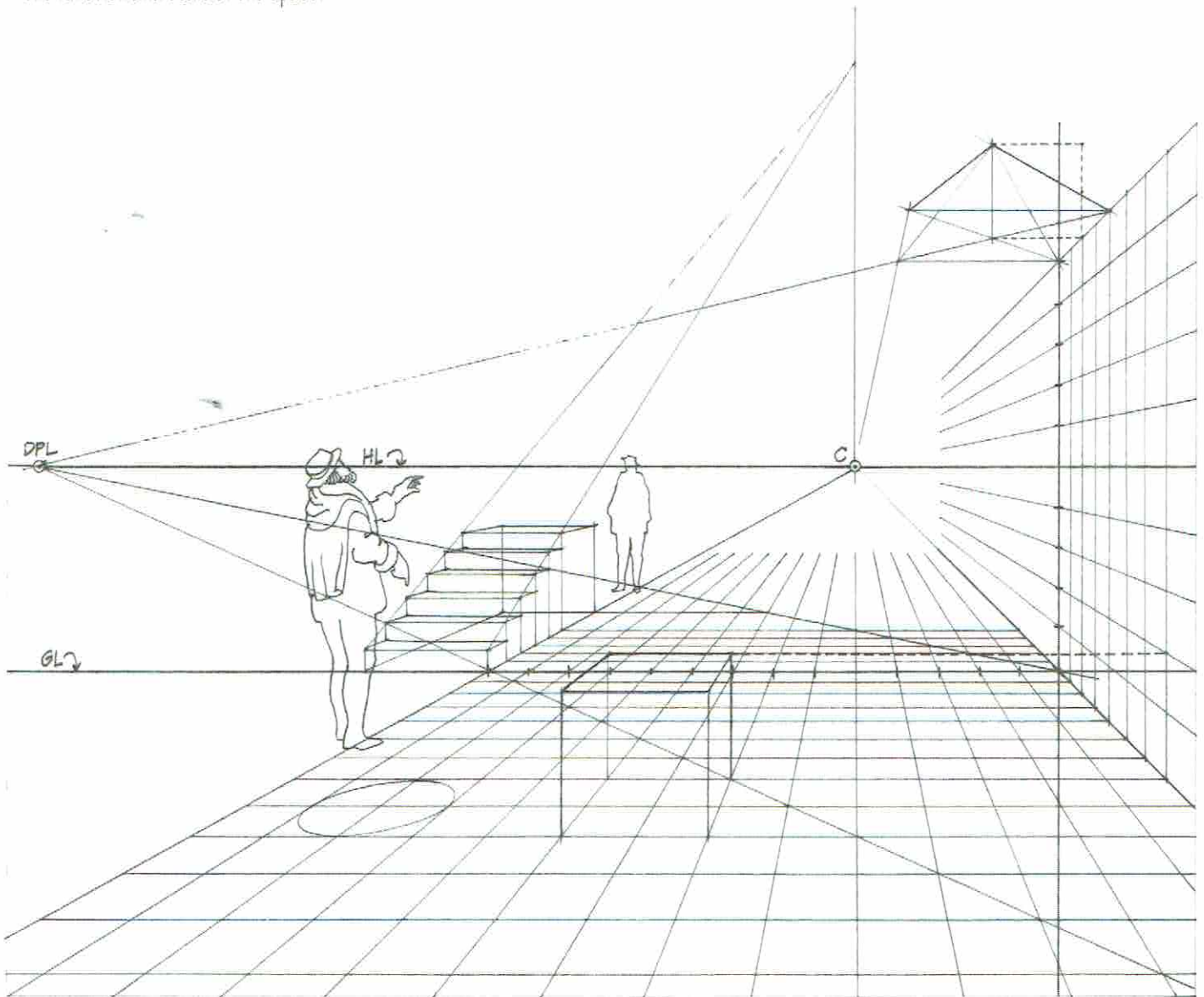


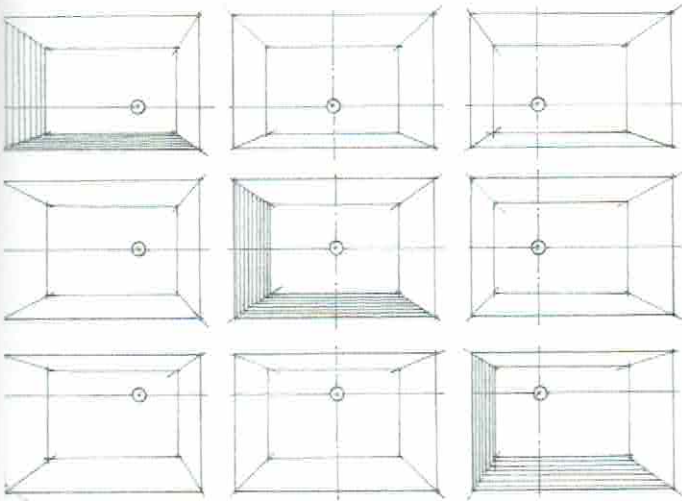
- Along HL, we establish DPL. Remember that the distance from DPL to C is equal to the distance of SP to C in the plan setup. Note that both DPL and DPR would serve the same purpose.
- From DPL, we draw a line through the left endpoint of the measurements along GL.
- Where this diagonal crosses the lines on the floor or ground plane that converge at C, we draw horizontal lines. The result is a perspective grid of one-foot squares on the floor or ground plane (GP).
- For depths beyond PP, we draw another diagonal to the other end of GL and follow a similar procedure.
- We can transfer these depth measurements and establish a similar grid along one or both receding sidewalls, as well as on a ceiling or overhead plane.
- A fractional distance point may be used if the drawing surface is too small to accommodate the normal distance point. A half-distance point will cut off two-foot increments in depth for every one-foot increment in width: $\frac{1}{2} DP = \frac{1}{2} (SP - C)$ in plan.

DIAGONAL POINT METHOD

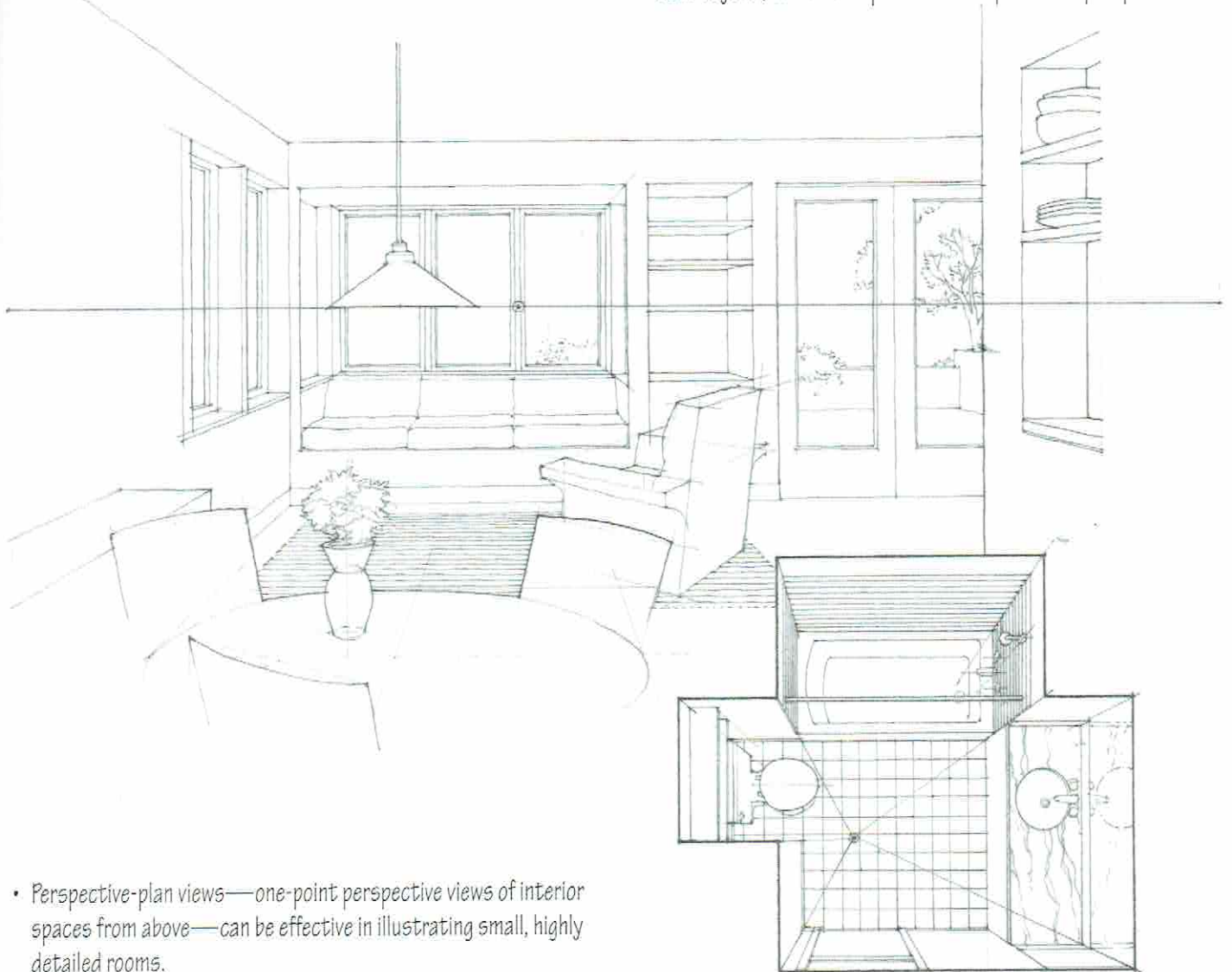
We can lay a piece of tracing paper over this perspective grid and draw in the major architectural elements of the space. With the same grid, we can also locate the positions and relative sizes of other elements within the space, such as furniture and lighting fixtures.

- We transfer measurements only along axial lines.
- For circles in perspective, see page 121.
- It's good practice to include people in our perspectives to indicate the function and scale of the space.



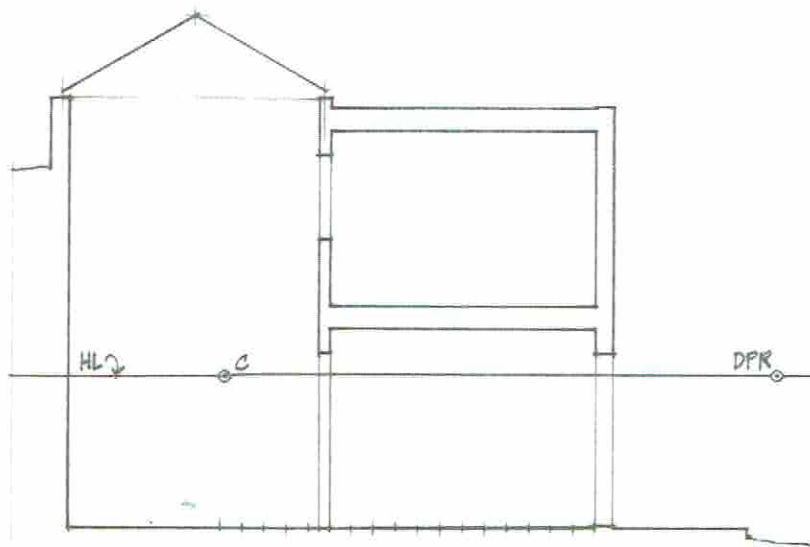


- When drawing a one-point perspective of a space, we notice that the observer's eye-level, equivalent to the height of the horizon line (HL) above the ground line (GL), as well as the location of the observer's center of vision (C), will determine which planes defining the space will be emphasized in the perspective view.
- The perspective drawing below uses the perspective grid shown on the facing page. Note that, particularly in interior views, properly cropped foreground elements can enhance the feeling that one is in a space rather than on the outside looking in. The center of vision (C) is closer to the lefthand wall so that the bending of the space to the right can be visualized. The change in scale between the righthand shelving and patio doors beyond, and a similar change between the foreground table and the window seat beyond, serve to emphasize the depth of the perspective.



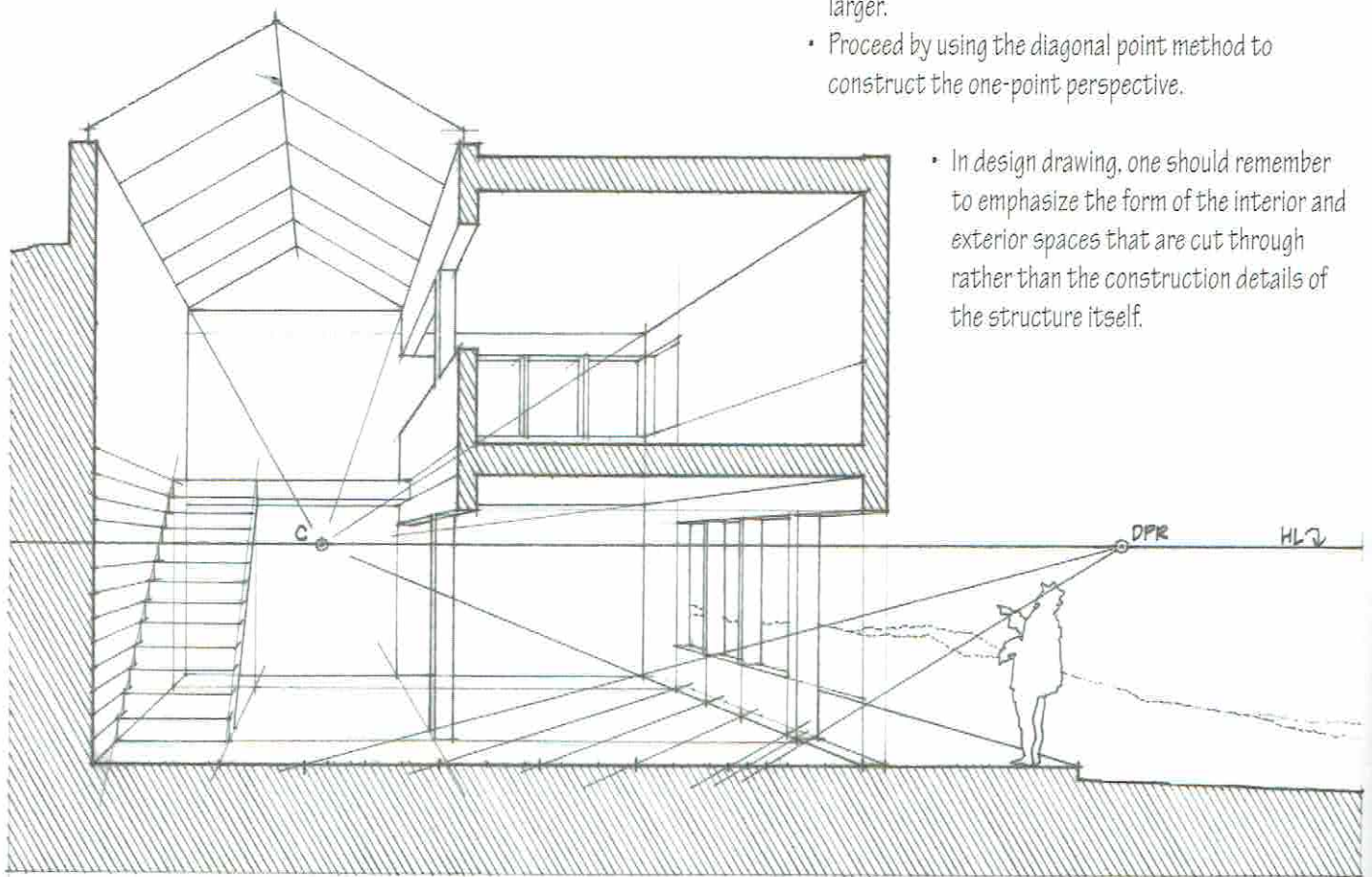
- Perspective-plan views—one-point perspective views of interior spaces from above—can be effective in illustrating small, highly detailed rooms.

SECTION PERSPECTIVES



The section perspective combines the scaled attributes of a section drawing and the pictorial depth of a perspective drawing. It therefore is able to illustrate both the constructional aspects of a design as well as the quality of the spaces formed by the structure.

- Begin a section perspective with a building section drawn at a convenient scale. Because the section cut is assumed to be coincident with the picture plane (PP) of the perspective, it serves as a ready reference for making vertical and horizontal measurements for the perspective drawing.
- Establish the horizon line (HL) and select a center of vision (C). The height of HL and position of C determine what is seen within the perspective view.
- On HL, establish the left and right diagonal points (DPL and DPR) for 45° lines. As a rule of thumb, the distance from C to DPL or DPR should be at least as great as the width or height of the building section, whichever is larger.
- Proceed by using the diagonal point method to construct the one-point perspective.

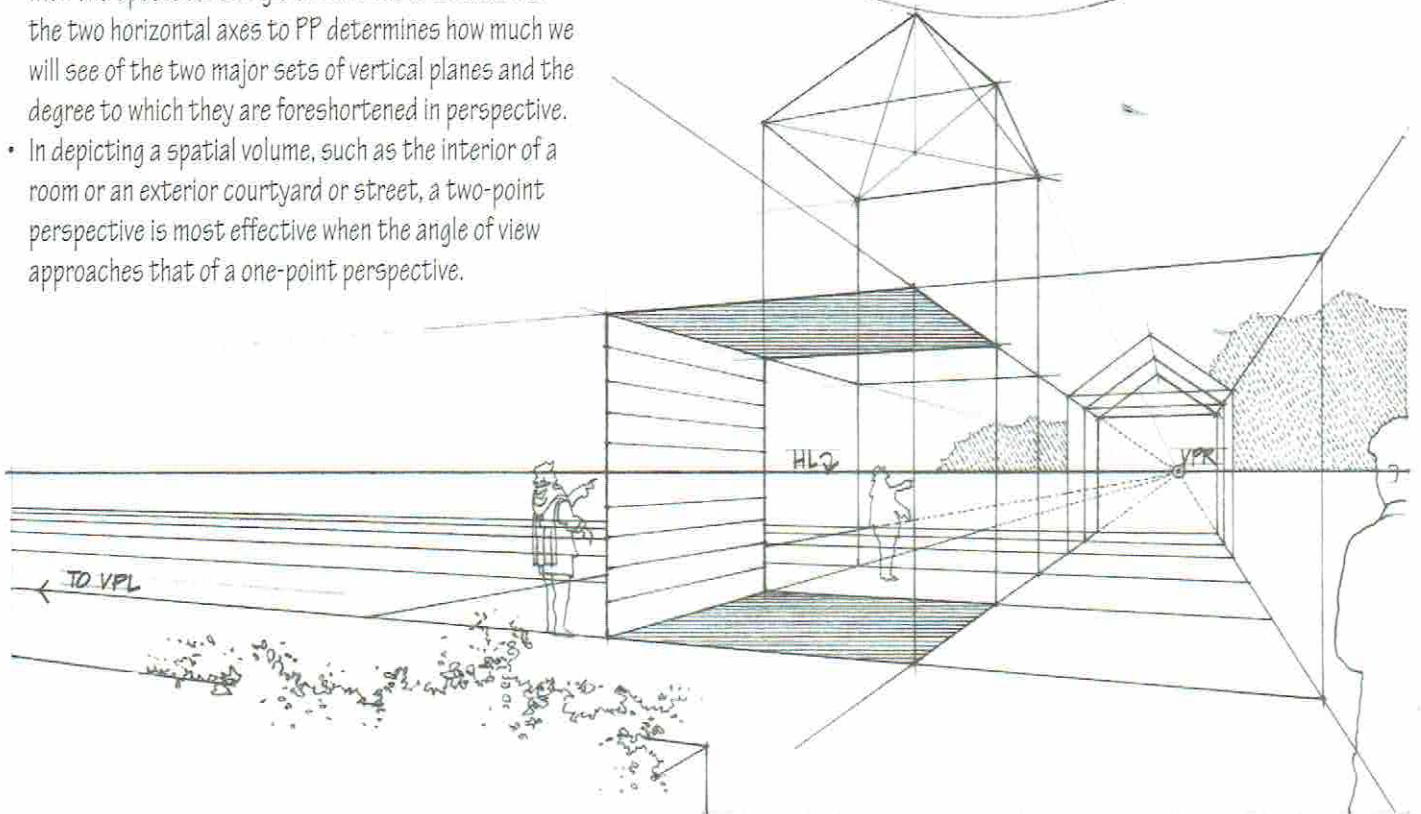
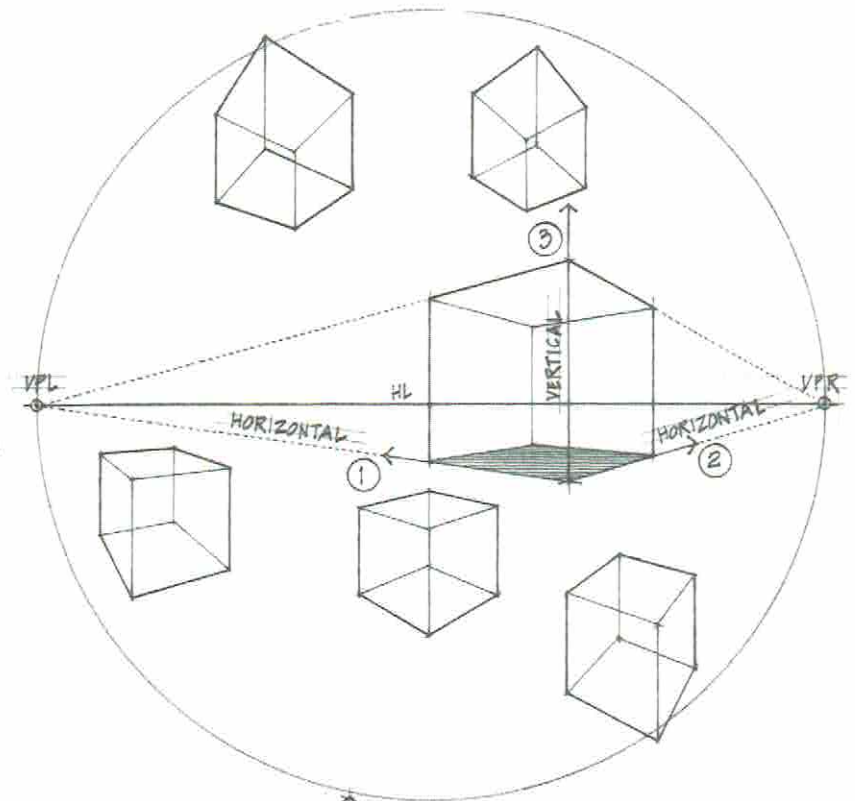


- In design drawing, one should remember to emphasize the form of the interior and exterior spaces that are cut through rather than the construction details of the structure itself.

The two-point perspective system assumes that the observer's central axis of vision (CAV) is horizontal and the picture plane (PP) is vertical. The principal vertical axis is parallel to PP, and all lines parallel to it remain vertical and parallel in the perspective drawing. The two principal horizontal axes, however, are oblique to PP. All lines parallel to these axes therefore appear to converge to two vanishing points on the horizon line (HL), one set to the left and the other to the right. These are the two points referred to in two-point perspective.

Two-point perspective is probably the most widely used of the three types of linear perspective. Unlike one-point perspectives, two-point perspectives tend to be neither symmetrical nor static. A two-point perspective is particularly effective in illustrating the three-dimensional form of objects in space ranging in scale from a chair to the massing of a building.

- The pictorial effect of a two-point perspective varies with the spectator's angle of view. The orientation of the two horizontal axes to PP determines how much we will see of the two major sets of vertical planes and the degree to which they are foreshortened in perspective.
- In depicting a spatial volume, such as the interior of a room or an exterior courtyard or street, a two-point perspective is most effective when the angle of view approaches that of a one-point perspective.

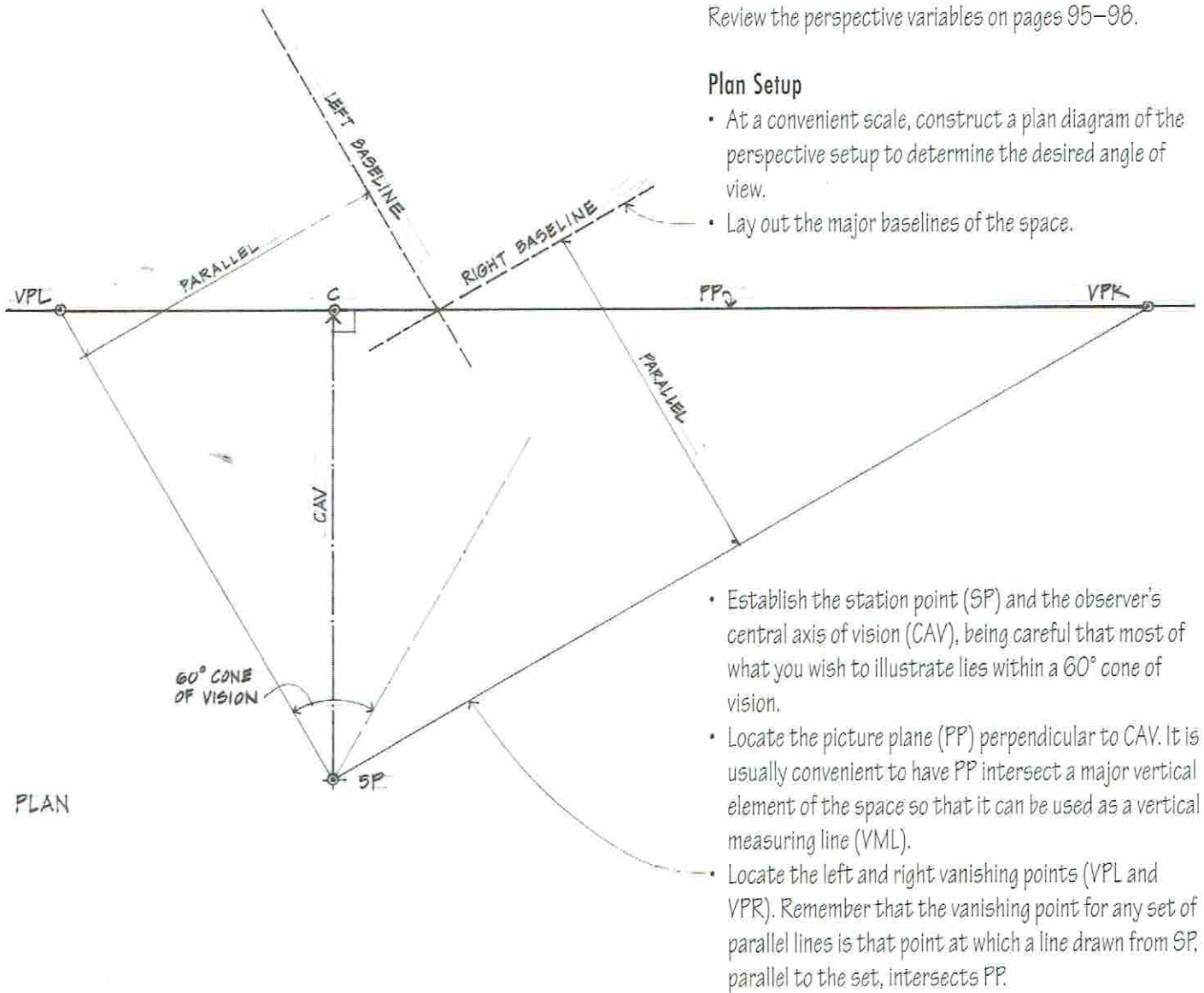


MEASURING POINT METHOD

The following is a method for constructing a two-point perspective grid utilizing measuring points. As with the construction of a one-point perspective, you should first establish the observer's point of view. Determine what you wish to illustrate. Look toward the most significant areas and try to visualize from your plan drawing what will be seen in the foreground, middleground, and background. Review the perspective variables on pages 95–98.

Plan Setup

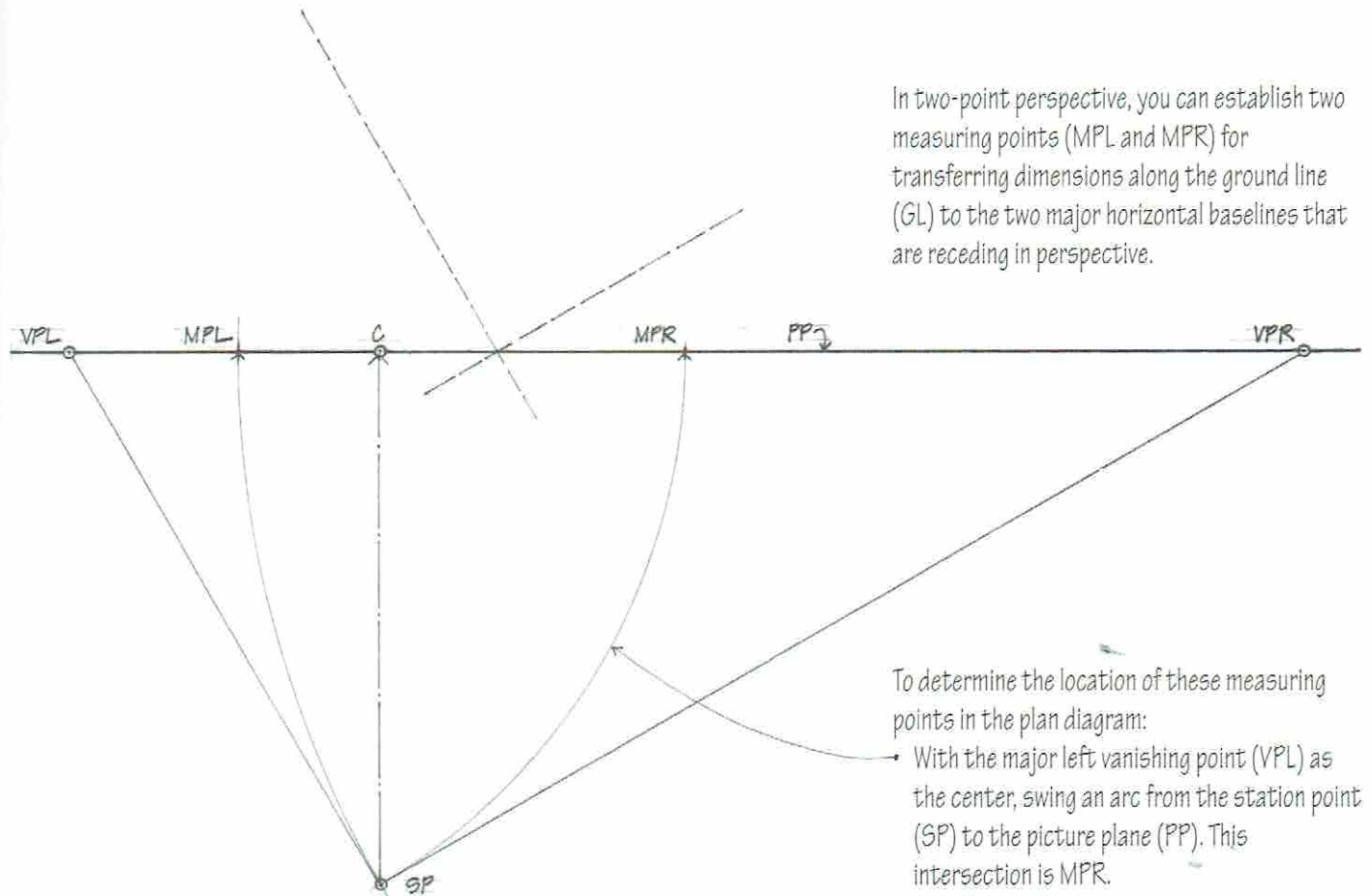
- At a convenient scale, construct a plan diagram of the perspective setup to determine the desired angle of view.
- Lay out the major baselines of the space.



- Establish the station point (SP) and the observer's central axis of vision (CAV), being careful that most of what you wish to illustrate lies within a 60° cone of vision.
- Locate the picture plane (PP) perpendicular to CAV. It is usually convenient to have PP intersect a major vertical element of the space so that it can be used as a vertical measuring line (VML).
- Locate the left and right vanishing points (VPL and VPR). Remember that the vanishing point for any set of parallel lines is that point at which a line drawn from SP, parallel to the set, intersects PP.

Measuring Points

A measuring point (MP) is a vanishing point for a set of parallel lines used to transfer true dimensions along a measuring line (ML) to a line receding in perspective. The diagonal point in one-point perspective is one example of such a measuring point.



In two-point perspective, you can establish two measuring points (MPL and MPR) for transferring dimensions along the ground line (GL) to the two major horizontal baselines that are receding in perspective.

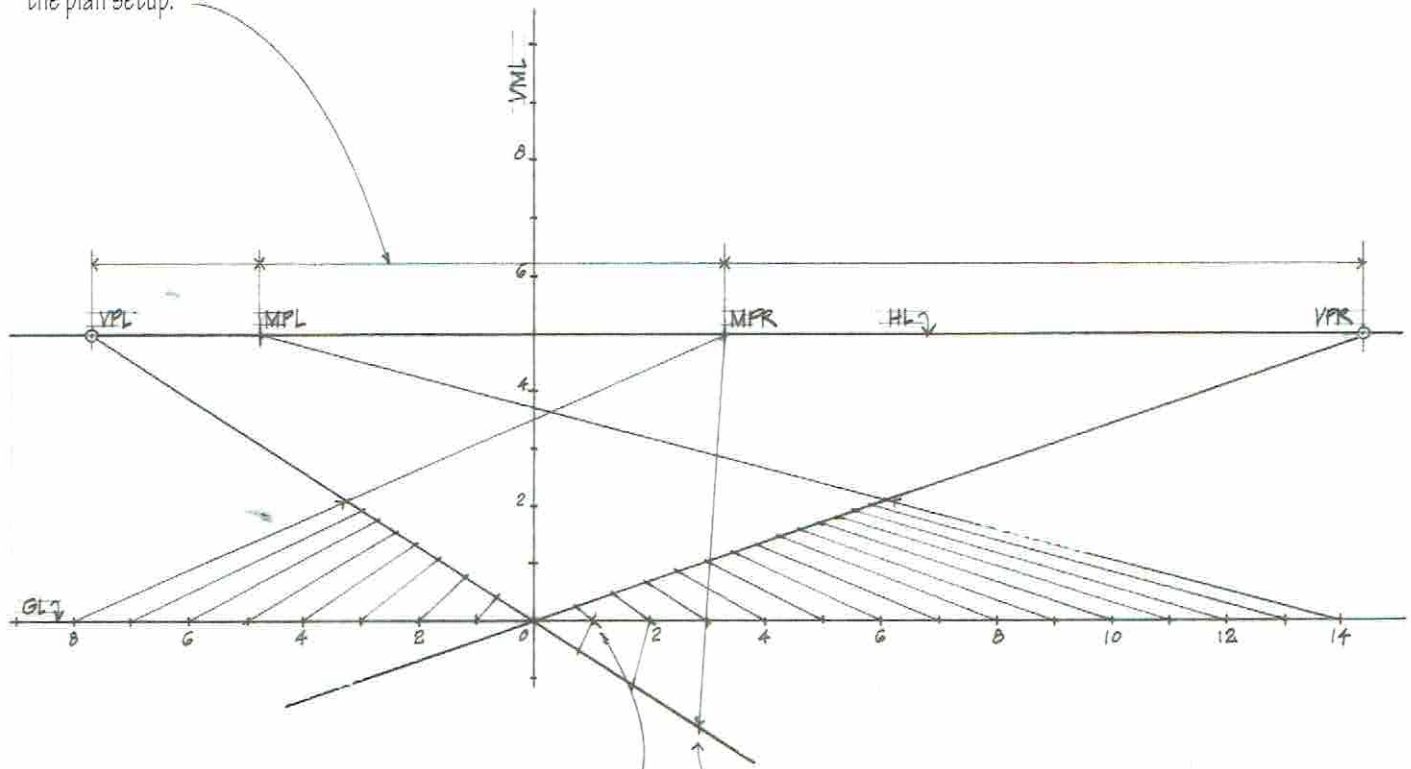
To determine the location of these measuring points in the plan diagram:

- With the major left vanishing point (VPL) as the center, swing an arc from the station point (SP) to the picture plane (PP). This intersection is MPR.
- With the major right vanishing point (VPR) as the center, swing an arc from the station point (SP) to the picture plane (PP) to locate MPL.
- Include vanishing points for secondary lines that might be useful in constructing your perspective. For example, if you have a series of parallel diagonals in your design, establish their vanishing point as well.

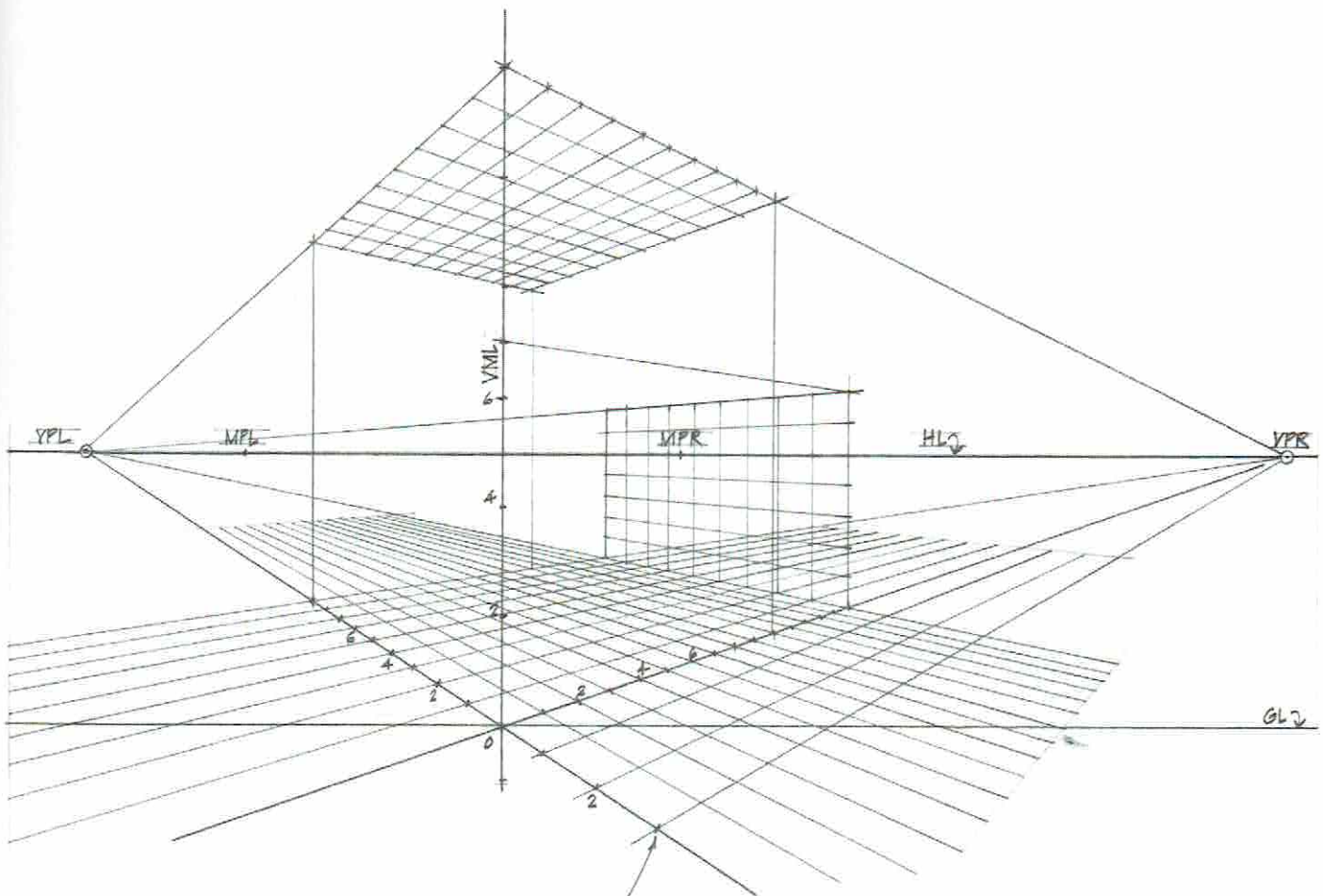
MEASURING POINT METHOD

Constructing the Perspective Grid

- Draw the horizon line (HL) and ground line (GL) at any convenient scale. This scale need not be the same as the scale of the plan setup.
- At the same scale, transfer the positions of the major left and right vanishing points (VPL and VPR) and the left and right measuring points (MPL and MPR) from the plan setup.



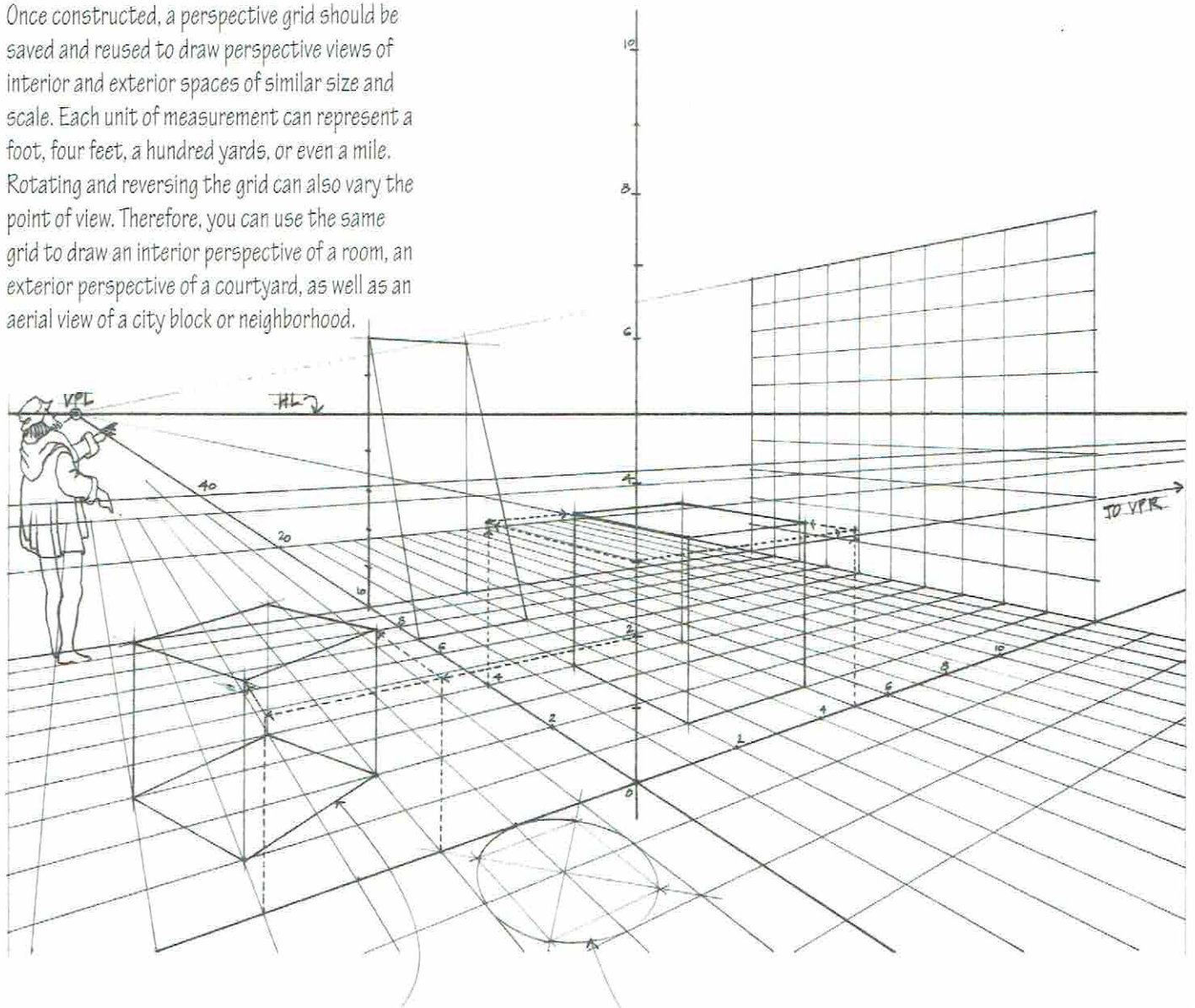
- Along GL, lay out equal increments of measurement to scale. The unit of measurement typically is one foot; we can use smaller or larger increments, however, depending on the scale of the drawing and the amount of detail desired in the perspective view.
- Establish the position of a vertical measuring line (VML) from the plan setup and lay out the same equal increments of measurement.
- From VPL and VPR draw baselines through the intersection of VML and GL.
- Transfer the units of measurements on GL to the left baseline in perspective by drawing lines to MPR. Transfer scale measurements on GL to the right baseline by drawing lines to MPL. These are construction lines used only to transfer scaled measurements along GL to the major horizontal baselines in perspective.
- A fractional measuring point can be used to reduce the length of measurements along GL. For example, you can use $\frac{1}{2}$ MPR to transfer a 5-foot measurement to a point 10 feet beyond the picture plane along the left baseline.



- From the major left and right vanishing points (VPL and VPR), draw lines through the transferred measurements along the major horizontal baselines in perspective.
- The result is a perspective grid of one-foot squares on the floor or ground plane. When one-foot squares become too small to draw accurately, use two-foot or four-foot squares instead.
- From VPL and VPR, draw lines through the scaled measurements along VML to establish a similar vertical grid.
- Over this perspective grid, you can lay tracing paper and draw a perspective view. It is important to see the perspective grid as a network of points and lines defining transparent planes in space rather than solid, opaque walls enclosing space. The grid of squares facilitates the plotting of points in three-dimensional space, regulates the perspective width, height, and depth of objects, and guides the drawing of lines in proper perspective.

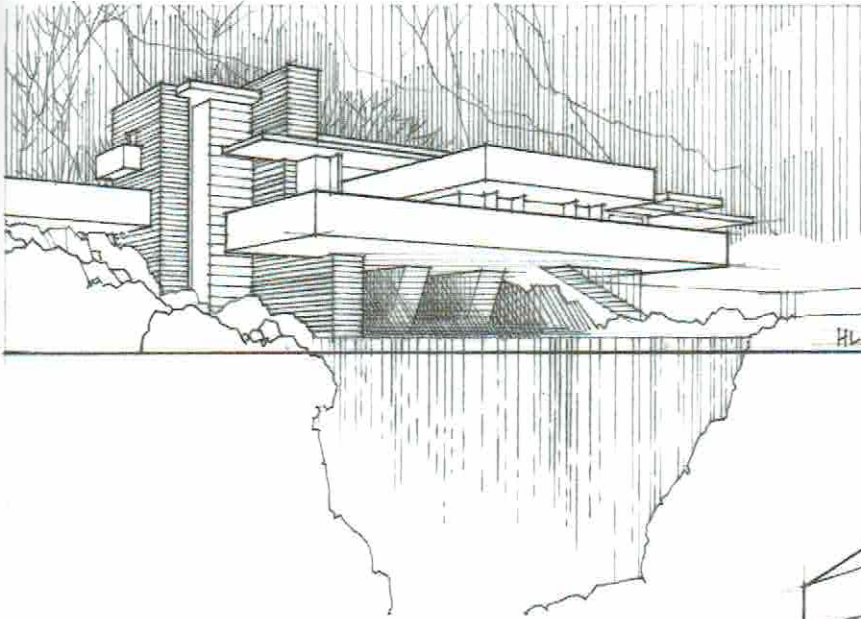
MEASURING POINT METHOD

Once constructed, a perspective grid should be saved and reused to draw perspective views of interior and exterior spaces of similar size and scale. Each unit of measurement can represent a foot, four feet, a hundred yards, or even a mile. Rotating and reversing the grid can also vary the point of view. Therefore, you can use the same grid to draw an interior perspective of a room, an exterior perspective of a courtyard, as well as an aerial view of a city block or neighborhood.

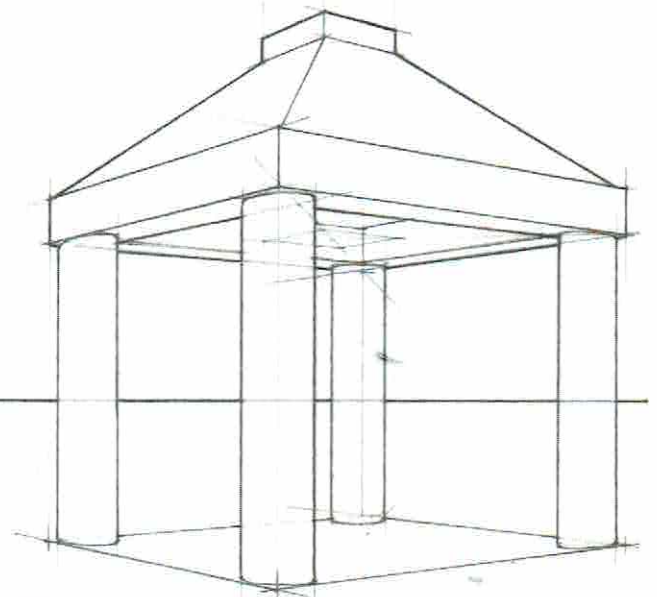


- To draw an object within a space, begin by laying out its plan or footprint on the grid of the ground or floor plane.
- Then elevate each of the corners to its perspective height using either a vertical grid or the known height of the horizon line (HL) above the ground line (GL).
- Complete the object by drawing its upper edges, using the principles of convergence and the grid lines to guide their direction.
- Remember to transfer all measurements only along axial lines.
- You can use the grid to plot inclined and curved lines as well.
- For inclined lines in perspective, see pages 118–19.
- For circles in perspective, see page 121.

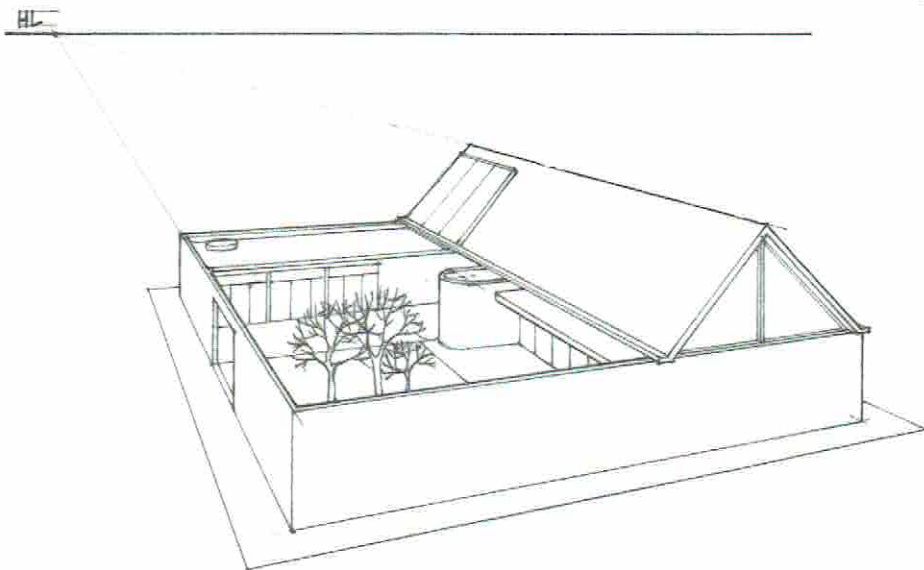
These three perspectives use the perspective grid shown on the preceding page. In each case, however, the height of the observer's station point (SP) above the ground plane (GP) has been selected to portray a specific point of view, and the scale of the grid has been altered to suit the scale of the structure.



- The observer views Frank Lloyd Wright's Kaufmann House, Falling Water, from the stream below the falls.

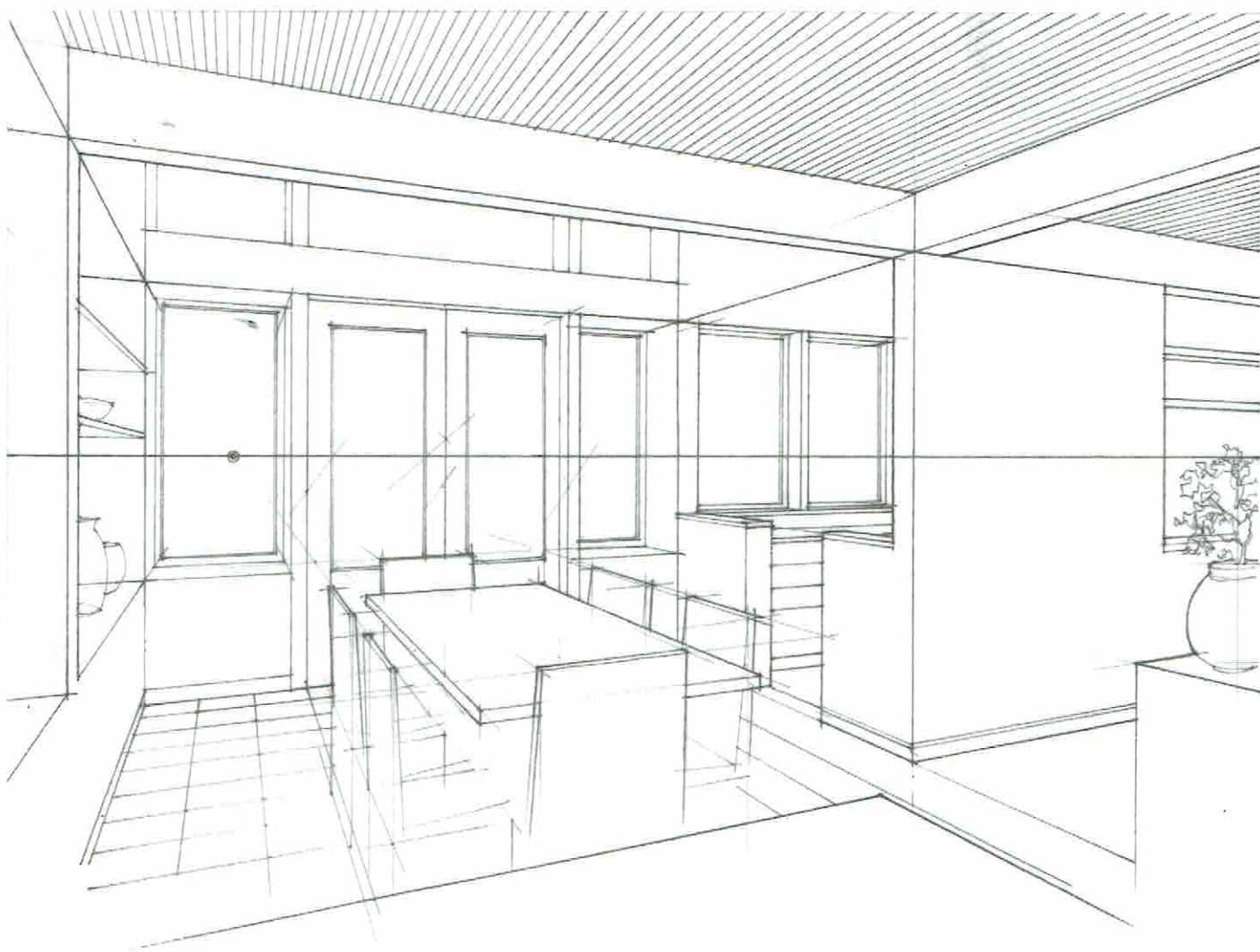


- This is a normal eye-level view—the one to which we are most accustomed.



- Here, a courtyard house is seen in an aerial view from above.

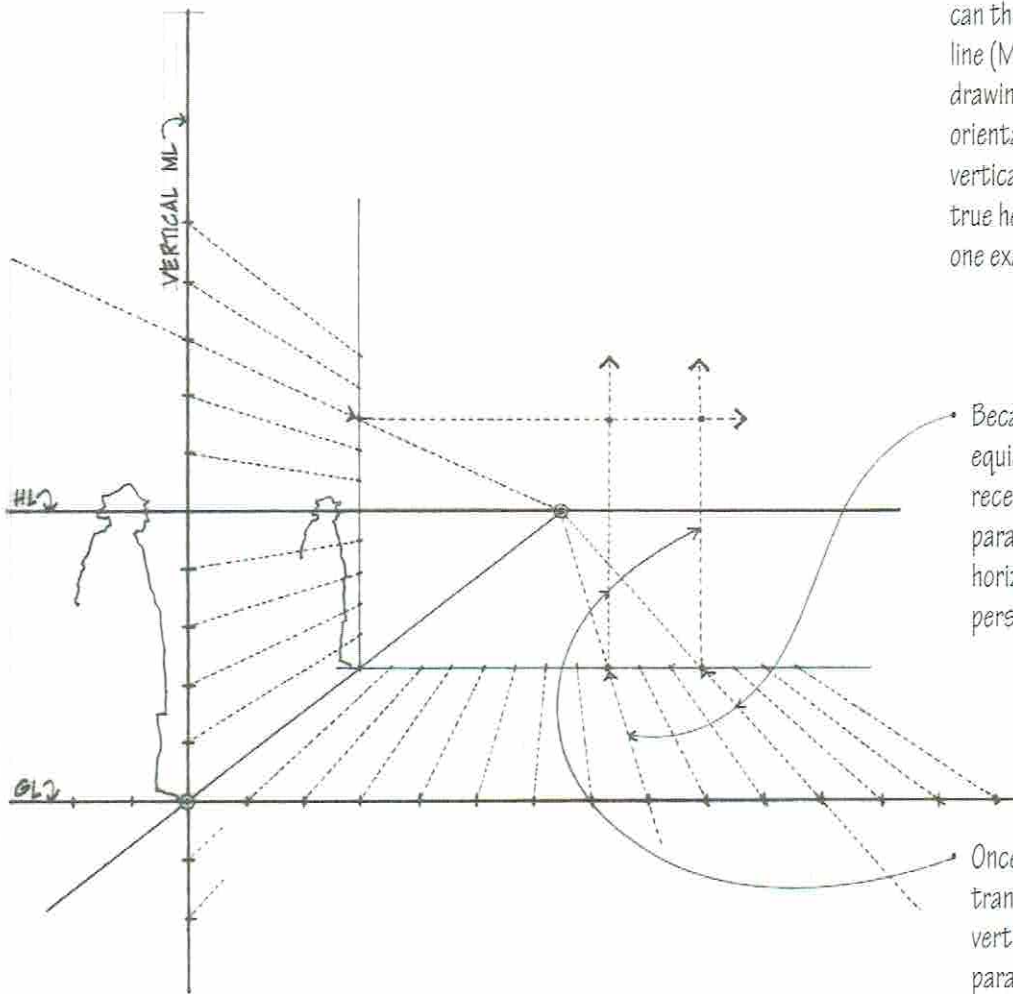
This interior perspective also uses the grid shown on page 112. Note that the left vanishing point (VPL) lies within the drawing, enabling three sides of the space to be shown and a greater sense of enclosure to be felt. Because VPL lies within the drawing, greater emphasis is placed on the right-hand portion of the space. If the left-hand side of the space is to be emphasized, use a reverse image of the grid.



The combined effects of convergence and diminishing size make it more difficult to establish and draw measurements in linear perspective than in the other two drawing systems. But there are techniques we can use to determine the relative heights, widths, and depths of objects in the pictorial space of a perspective drawing.

Measuring Height and Width

In linear perspective, any line in the picture plane (PP) displays its true direction and true length at scale of the picture plane. We can therefore use any such line as a measuring line (ML) to scale dimensions in a perspective drawing. While a measuring line may have any orientation in the picture plane, it typically is vertical or horizontal and used to measure true heights or widths. The ground line (GL) is one example of a horizontal measuring line.

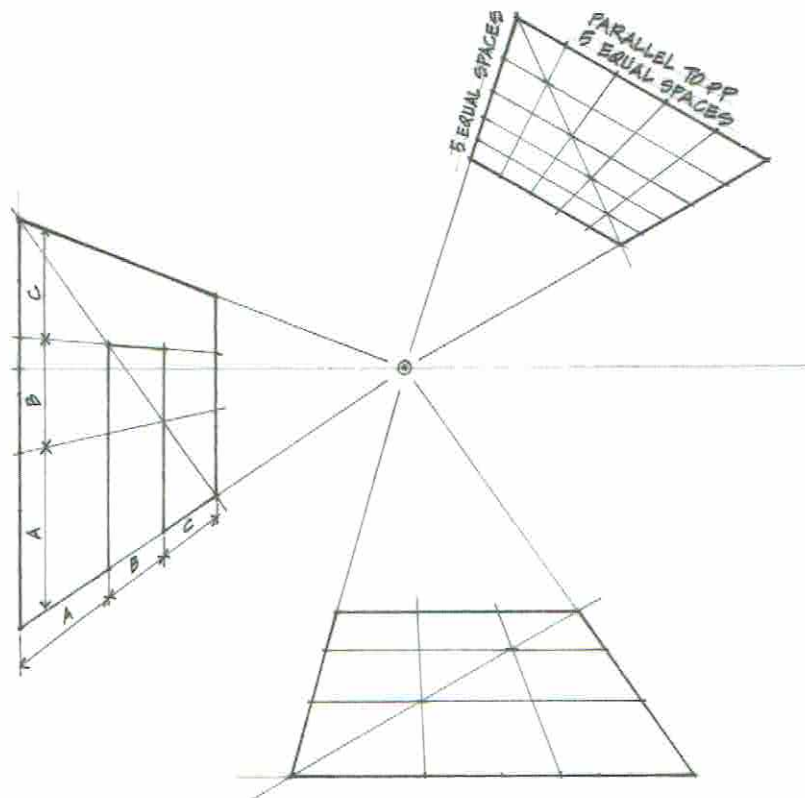
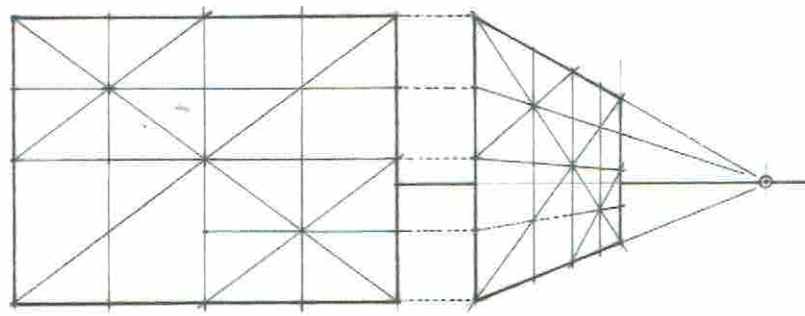
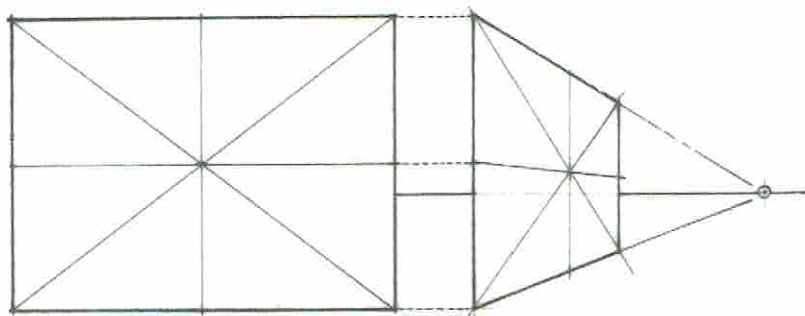


Because parallel lines by definition remain equidistant but appear to converge as they recede in perspective, we can use a pair of parallel lines to transfer a vertical or horizontal measurement into the depth of a perspective.

Once we establish a height or width, we can transfer the measurement horizontally or vertically, as long as we make the shift parallel to PP.

Digital Perspectives

Perspective measurements are not a major issue in 3D-modeling programs because the software uses mathematical formulas to process the three-dimensional data we have already entered.



Measuring Depth

Measuring perspective depth is more difficult than gauging heights and widths in linear perspective. Various methods of perspective construction establish depth in different ways. Once we establish an initial depth judgment, however, we can make succeeding depth judgments in proportion to the first.

Subdividing Depth Measurements

There are two methods for subdividing depth measurements in linear perspective: the method of diagonals and the method of triangles.

Method of Diagonals

In any projection system, we can subdivide a rectangle into four equal parts by drawing two diagonals.

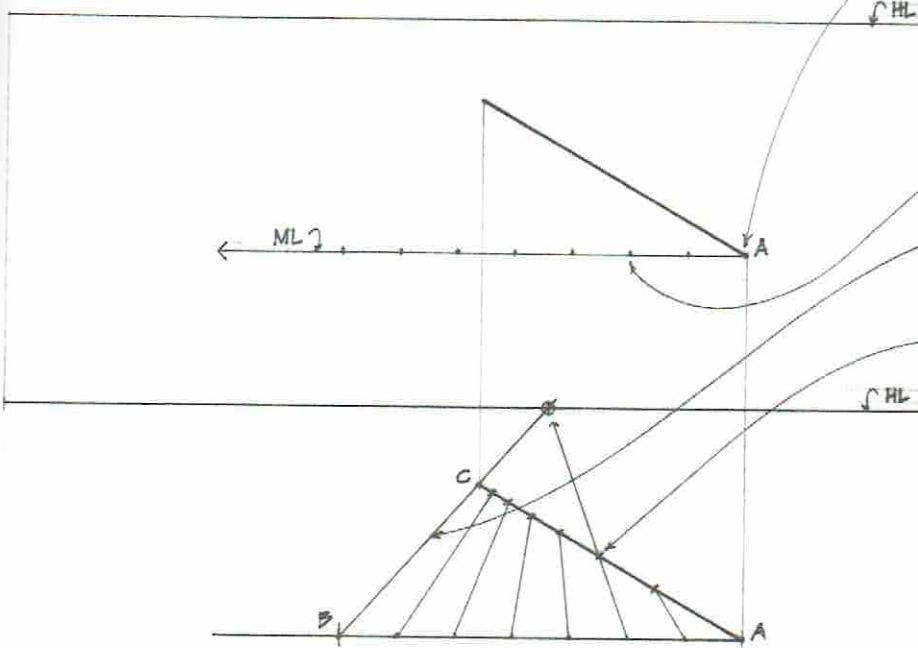
- For example, if we draw two diagonals across a rectangular plane in perspective, they will intersect at the geometric center of the plane. Lines drawn through this midpoint, parallel to the edges of the plane, will subdivide the rectangle and its receding sides into equal parts. We can repeat this procedure to subdivide a rectangle into any even number of parts.

To subdivide a rectangle into an odd number of equal parts, or to subdivide its receding edges into a series of unequal segments, its forward edge must be parallel to the picture plane (PP) so that it can be used as a measuring line (ML).

- On the forward edge of the rectangle, we mark off the same proportional subdivisions to be made in the depth of the perspective.
- From each of the marked points, we draw parallel lines that converge at the same point as the receding edges of the plane.
- Then we draw a single diagonal.
- At each point where this diagonal crosses the series of receding lines, we draw lines parallel to the forward edge. These mark off the desired spaces, which diminish as they recede in perspective.
- If the rectangle is a square, then the subdivisions are equal; otherwise, the segments are proportional but not equal.

Method of Triangles

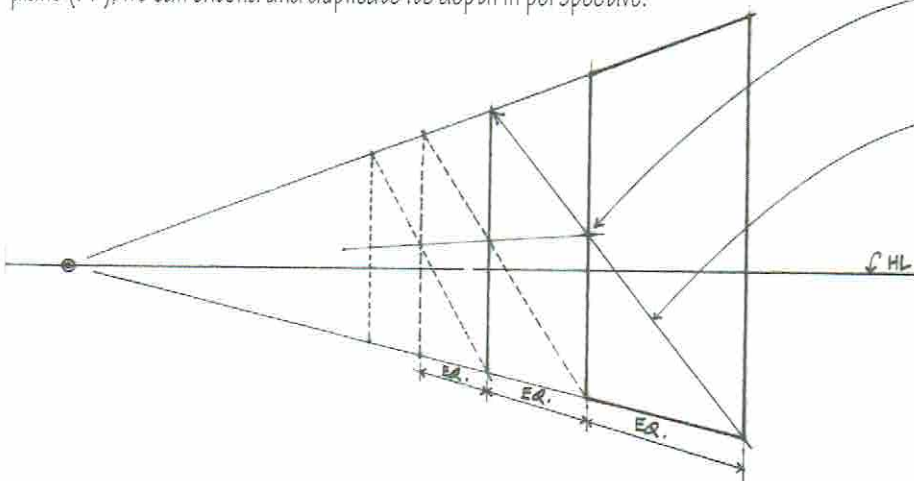
Because any line parallel to the picture plane (PP) can be subdivided proportionately to scale, we can use such a parallel line as a measuring line (ML) to subdivide any intersecting line into equal or unequal parts.



- From one end (A) of the receding line to be subdivided, we draw a measuring line (ML) parallel to PP. If the receding line is horizontal in space, then ML will be a horizontal line in the drawing.
- At an appropriate scale, we mark off the desired subdivisions on ML.
- We define a triangle by connecting the end (B) of ML and the end (C) of the receding line.
- From each of the scaled subdivisions, we draw lines that are parallel to BC and therefore converge at the same vanishing point. These lines subdivide the receding line into the same proportional segments.

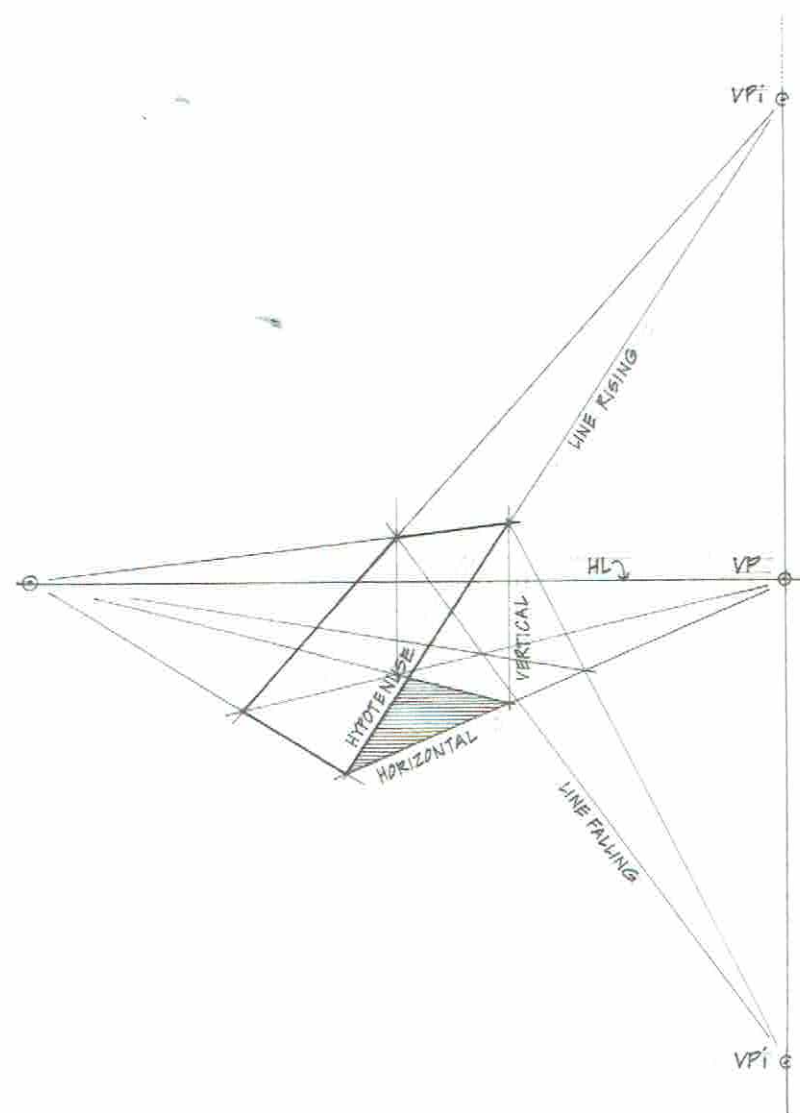
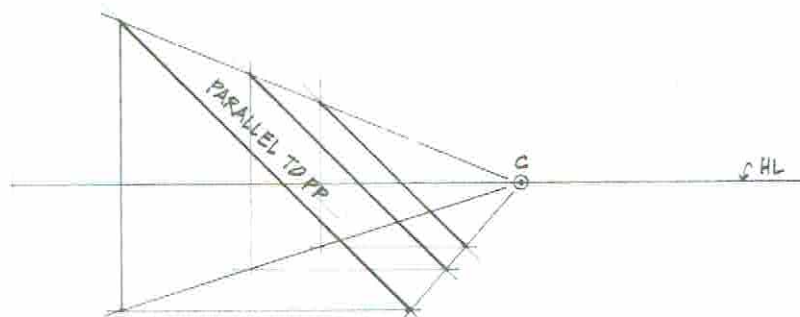
Extending a Depth Measurement

If the forward edge of a rectangular plane is parallel to the picture plane (PP), we can extend and duplicate its depth in perspective.



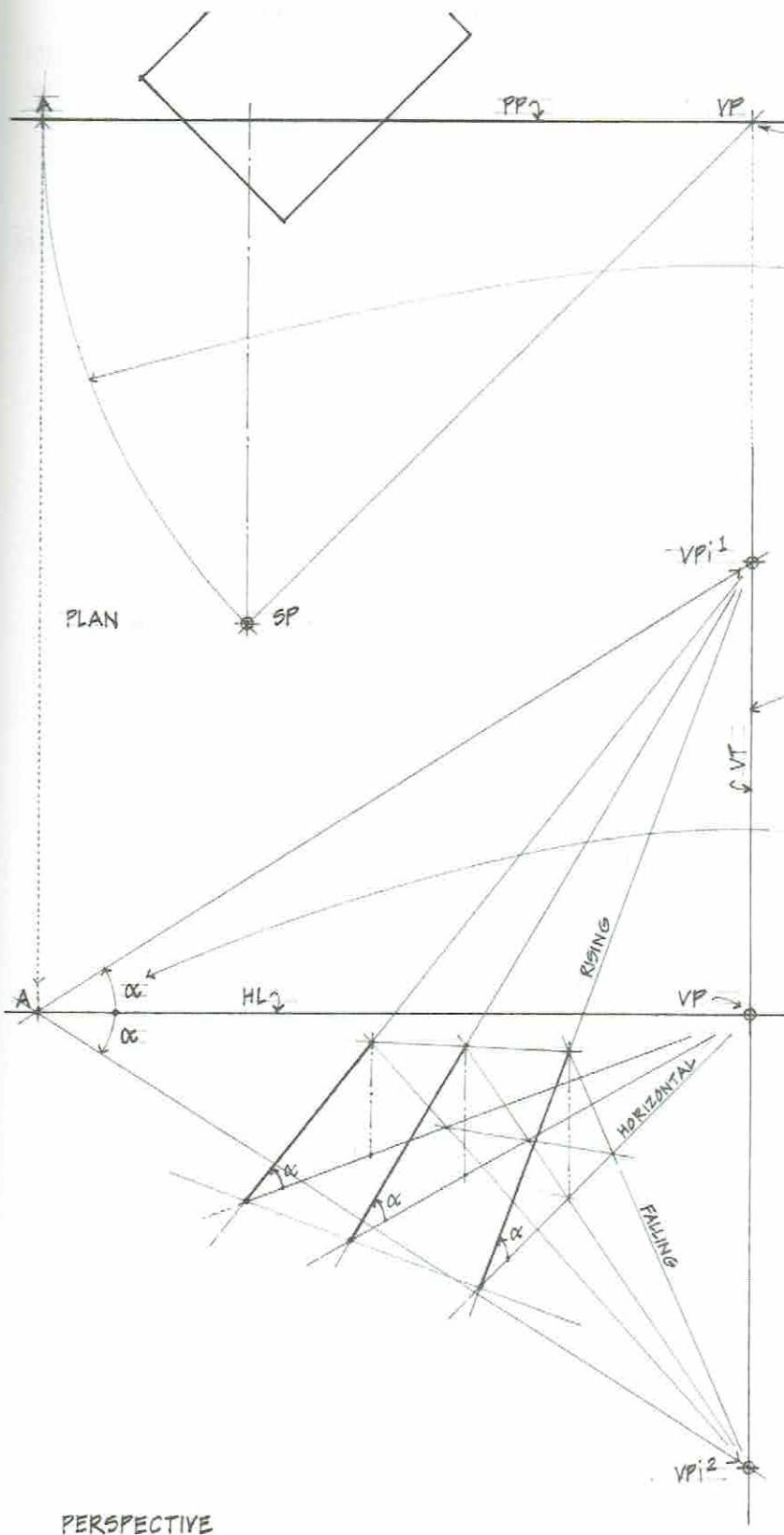
- Note that it is usually better to subdivide a larger measurement into equal parts than it is to multiply a smaller measurement to arrive at a larger whole. The reason for this is that, in the latter procedure, even minute errors can accumulate and become visible in the overall measurement.

- First, we establish the midpoint of the rear edge opposite the forward edge of the rectangle.
- Then we extend a diagonal from a forward corner through this midpoint to meet an extended side of the rectangle.
- From this point, we draw a line parallel to the forward edge. The distance from the first to the second edge is identical to the distance from the second to the third edge, but the equal spaces are foreshortened in perspective.
- We can repeat this procedure as often as necessary to produce the desired number of equal spaces in the depth of a perspective drawing.



Once we are familiar with how lines parallel to the three principal axes of an object converge in linear perspective, we can use this rectilinear geometry as the basis for drawing perspective views of inclined lines, circles, and irregular shapes.

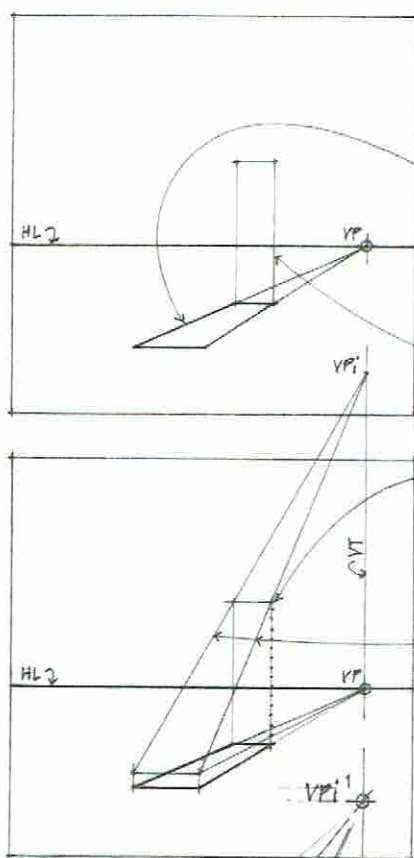
- Inclined lines parallel to the picture plane (PP) retain their orientation but diminish in size according to their distance from the spectator. If perpendicular or oblique to PP, however, an inclined set of lines will appear to converge at a vanishing point above or below the horizon line (HL).
- We can draw any inclined line in perspective by first finding the perspective projections of its end points and then connecting them. The easiest way to do this is to visualize the inclined line as being the hypotenuse of a right triangle. If we can draw the sides of the triangle in proper perspective, we can connect the end points to establish the inclined line.
- If we must draw a number of inclined parallel lines, as in the case of a sloping roof, a ramp, or a stairway, it is useful to know where the inclined set appears to converge in perspective. An inclined set of parallel lines is not horizontal and therefore will not converge on HL. If the set rises upward as it recedes, its vanishing point will be above HL; if it falls as it recedes, it will appear to converge below HL.
- An expedient method for determining the vanishing point for an inclined set of lines (VPi) is to extend one of the inclined lines until it intersects a vertical line drawn through the vanishing point (VP) for a horizontal line lying in the same vertical plane. This intersection is the vanishing point (VPi) for the inclined line and all other lines parallel to it.



A more precise method for determining the vanishing point for an inclined set of parallel lines is as follows:

- In the plan view of the perspective setup, we determine the vanishing point (VP) for a horizontal line in the same vertical plane as one of the inclined lines.
- With VP as the center, we swing an arc from the station point (SP) to the picture plane (PP). Mark this point A.
- In the perspective view, we mark point A along the horizon line (HL).
- A vanishing trace (VT) is a line along which all sets of parallel lines within a plane will appear to converge in linear perspective. The horizon line, for example, is the vanishing trace along which all horizontal sets of parallel lines converge.
- We establish a vertical vanishing trace (VT) through VP. This is the vanishing trace for the vertical plane containing the inclined set of parallel lines.
- From point A, we draw a line at the true slope (α) of the inclined set.
- The point at which this line intersects VT is the vanishing point (VPI) for the inclined set of parallel lines.
- The steeper the inclined set of parallel lines, the farther up or down on its vanishing trace (VT) will be its vanishing point (VPI).
- Note that if an inclined set of parallel lines rises upward and another set in the same vertical plane falls at the same but opposite angle to the horizontal, the distances of their respective vanishing points (VPI1 and VPI2) above and below the horizon line (HL) are equal.

Drawing stairs in perspective is easiest when we can determine the vanishing point for the inclined lines that connect the stair nosings.



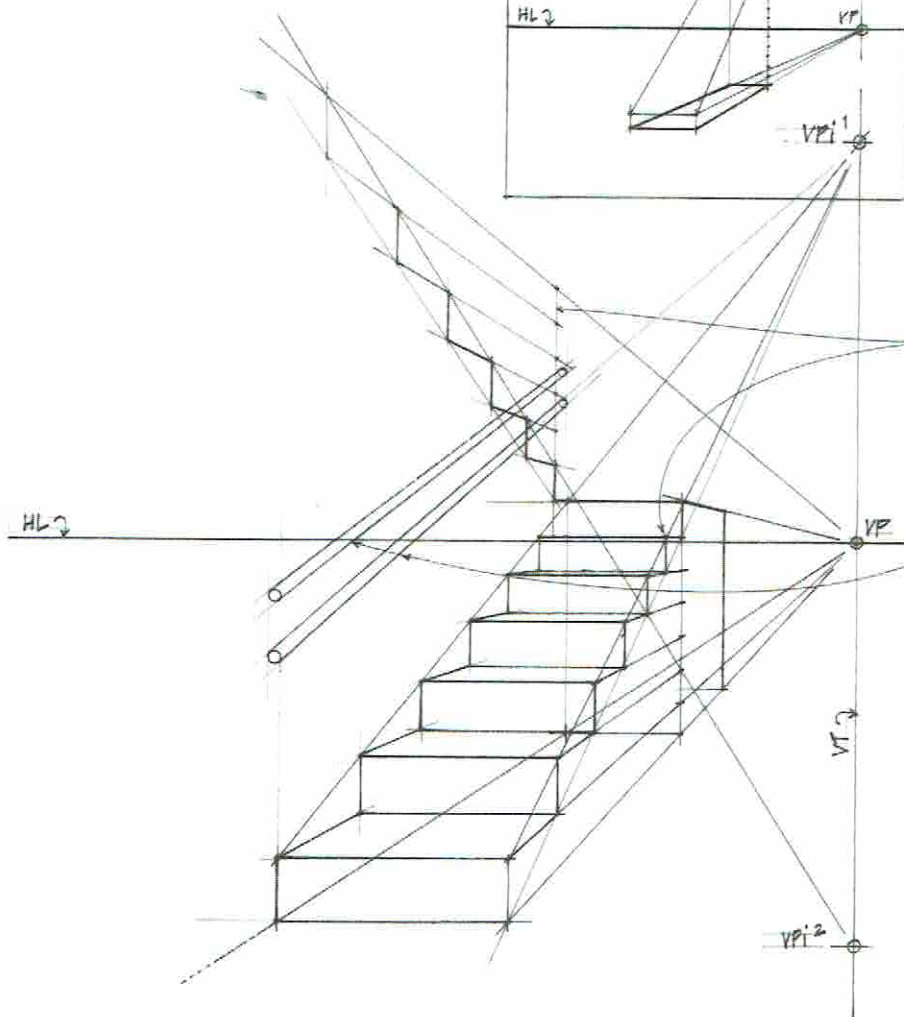
We first lay out the perspective view of the horizontal stair run on the floor plane. We are not concerned yet with the individual treads of the stairway.

We then extend a vertical plane to the height of the stair landing or next floor level.

Next we divide one side of this plane into the number of equal risers in the stair run.

We can determine the height of the first riser in perspective.

We draw an inclined line from the top of the first riser to the top of the landing or upper floor level.

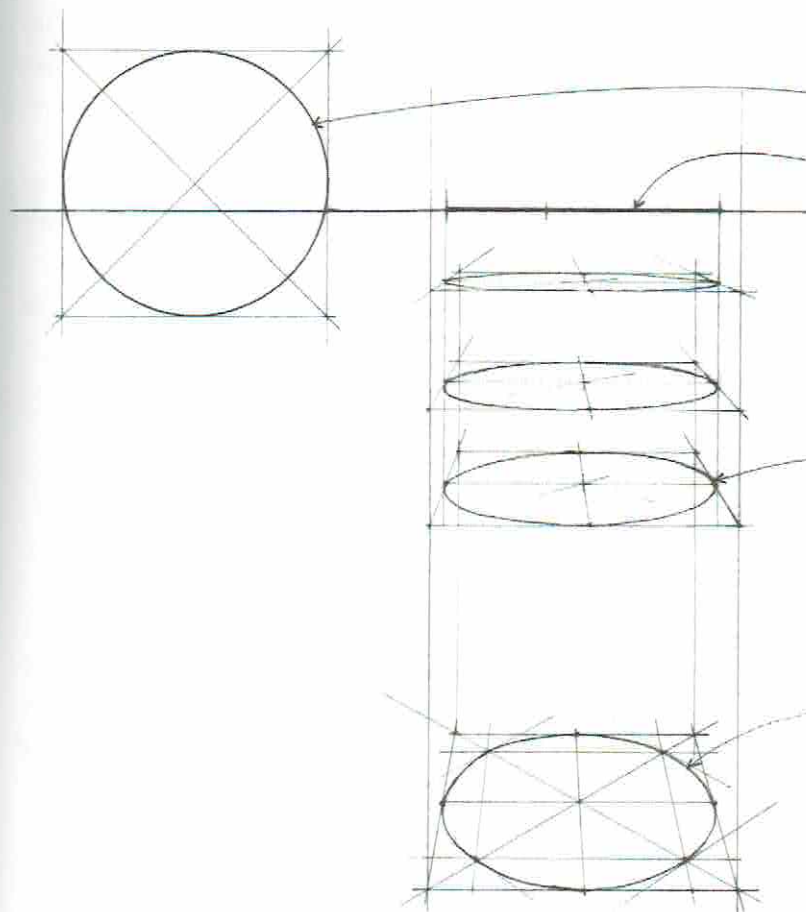


This inclined line is subdivided by extending horizontal lines from the riser markings.

From these points, we draw the risers and treads as vertical and horizontal planes in perspective.

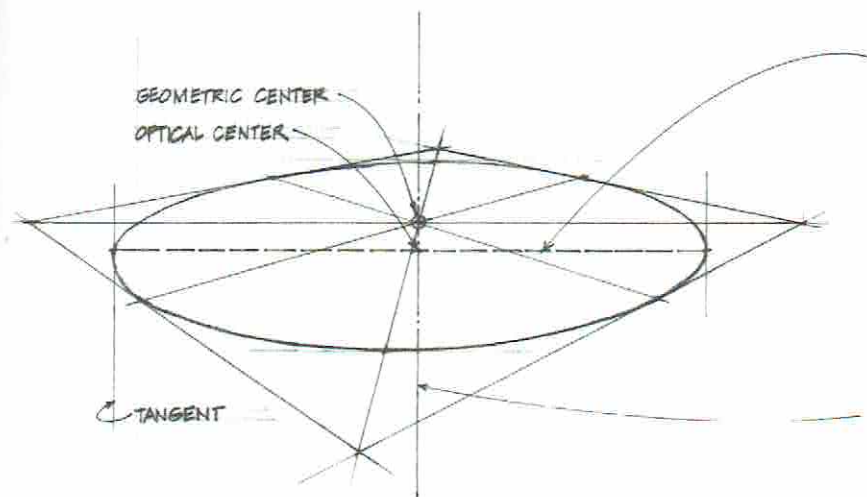
We can use the vanishing points for inclined lines to draw other elements parallel to the inclined lines, such as stair stringers and railings.

The circle is the essential basis for drawing cylindrical objects, arches, and other circular forms.

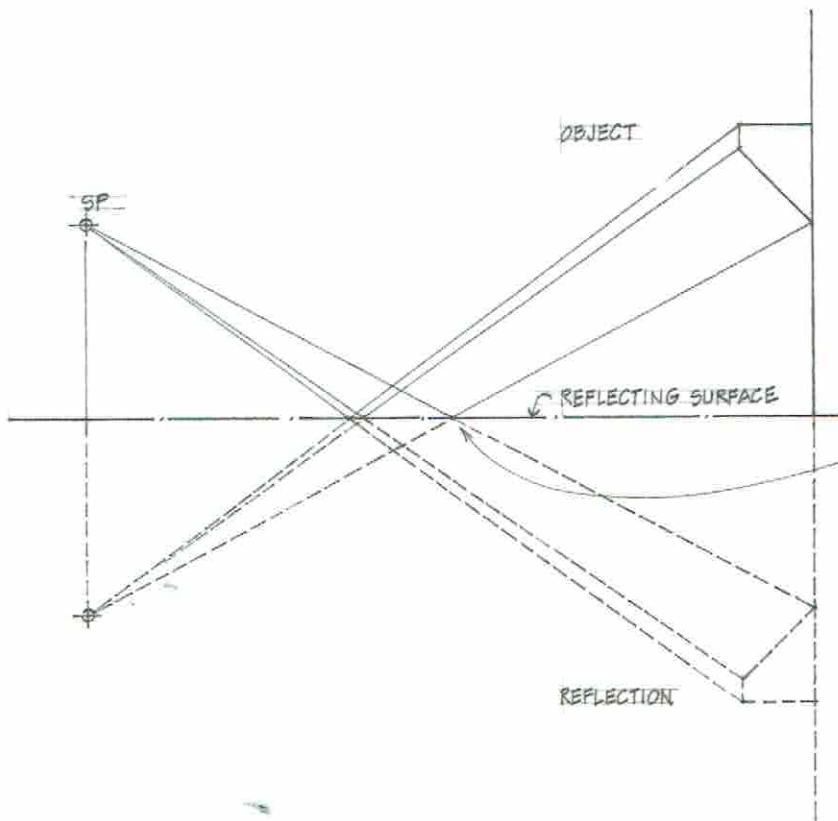


- The perspective view of a circle remains a circle when it is parallel to the picture plane (PP).
- The perspective view of a circle is a straight line when the sightlines radiating from the station point (SP) are parallel to the plane of the circle. This occurs most frequently when the plane of the circle is horizontal and at the height of the horizon line (HL), or when the plane of the circle is vertical and aligned with the central axis of vision (CAV).
- In all other cases, circles appear as elliptical shapes in perspective.

- To draw a circle in perspective, we first draw a perspective view of a square that circumscribes the circle.
- Then we construct the diagonals of the square and indicate where the circle crosses the diagonals with additional lines parallel to the sides of the square or tangent to the circumference of the circle. The larger the circle, the more subdivisions are necessary to ensure smoothness of the elliptical shape.



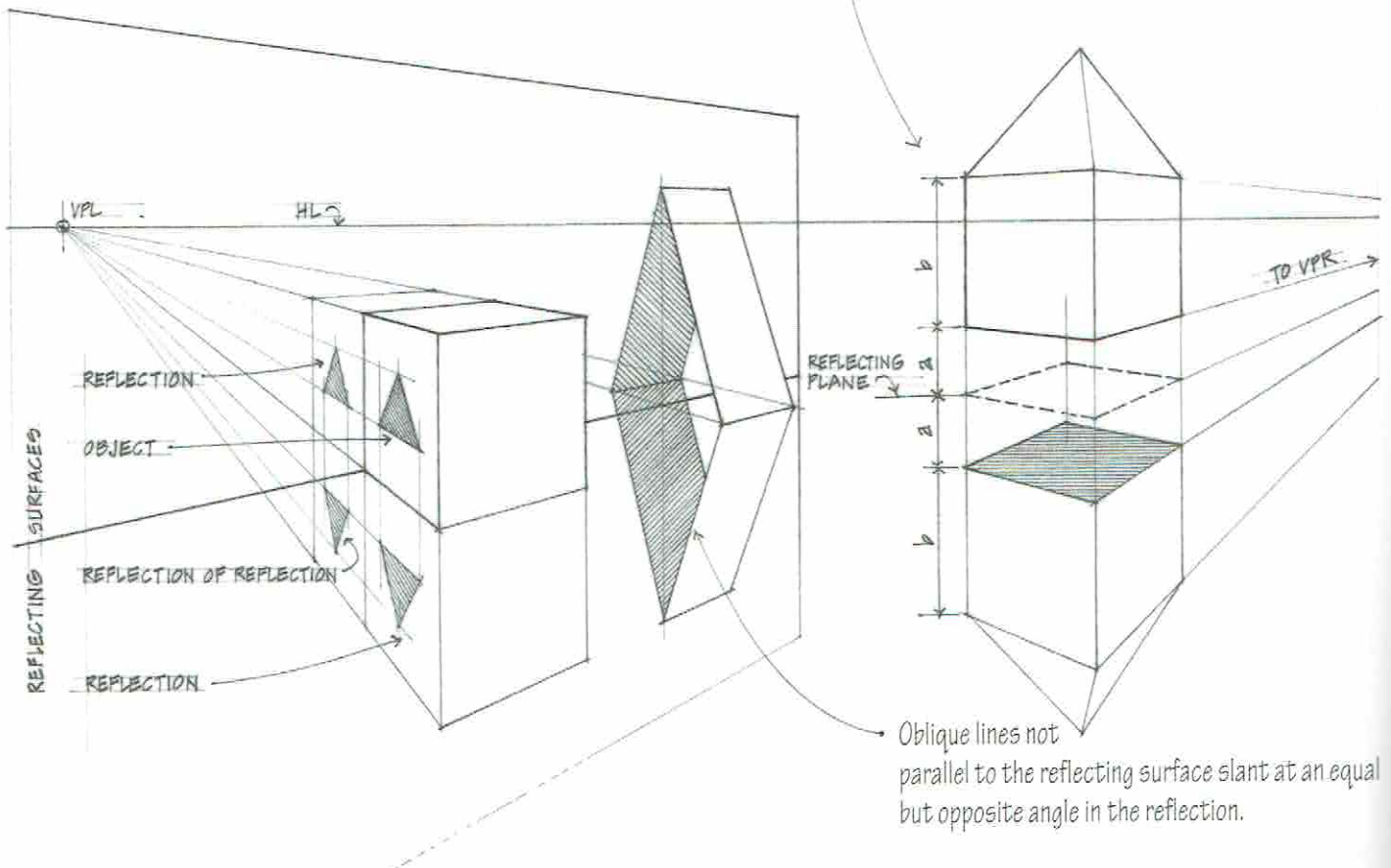
- Note that the major axis of the ellipse representing the circle in perspective is not coincident with the geometric diameter of the circle.
- We tend to see things as we believe them to be. So while a circle in perspective appears to be an ellipse, we tend to see it in the mind's eye as a circle, and thus exaggerate the length of its minor axis.
- The minor axis should appear to be perpendicular to the plane of the circle. Checking the relationship between the major and minor axes of elliptical shapes helps to ensure accuracy of the foreshortening of circles in perspective.



Reflections occur on the horizontal surfaces of bodies of water, the mirrored surfaces of glass, and the polished surfaces of floors. A reflecting surface presents an inverted or mirror image of the object being reflected. For example, if an object is resting directly on a reflecting surface, the reflected image is a direct, inverted copy of the original. Thus, in a perspective view of the reflection, the reflected image follows the same perspective system of lines already established for the original image.

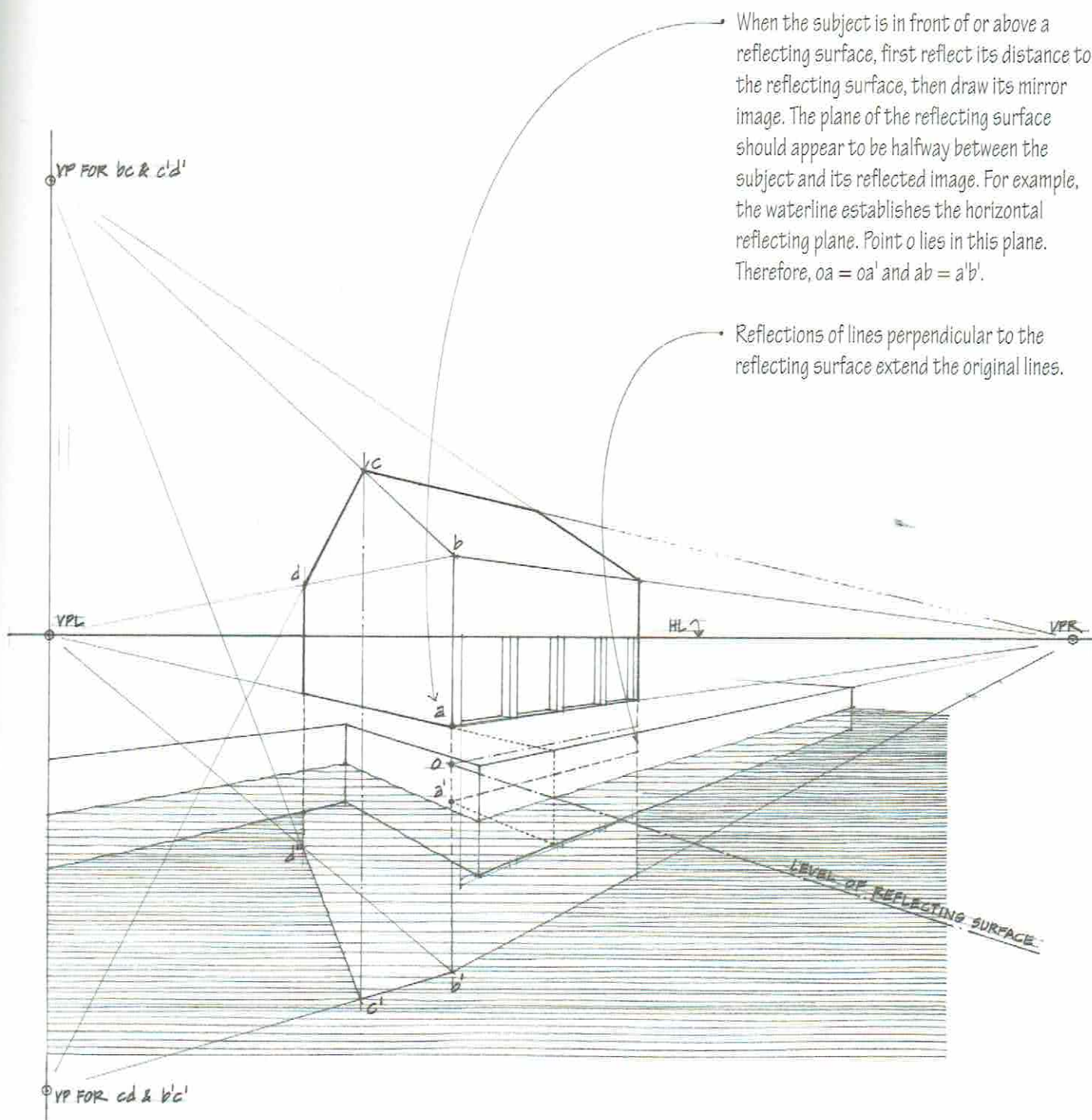
Sightlines reflect off a mirrored surface at an angle equal to the angle of incidence. Each reflection therefore doubles the apparent dimension of the space in a direction perpendicular to the mirrored surface.

Anything in front of or above a reflecting surface appears at the same distance in back of or below the reflecting surface in a direction perpendicular to the surface.



Oblique lines not parallel to the reflecting surface slant at an equal but opposite angle in the reflection.

Any reflecting planar surface parallel to one of the three major axes extends the perspective system of the subject. Therefore, the major sets of parallel lines in the reflection appear to converge to the same vanishing points as do the corresponding sets of lines in the subject.



When the subject is in front of or above a reflecting surface, first reflect its distance to the reflecting surface, then draw its mirror image. The plane of the reflecting surface should appear to be halfway between the subject and its reflected image. For example, the waterline establishes the horizontal reflecting plane. Point o lies in this plane. Therefore, $oa = oa'$ and $ab = a'b'$.

Reflections of lines perpendicular to the reflecting surface extend the original lines.

When drawing a perspective of an interior space having a mirrored surface on one or more of its major planes, we extend the perspective system in the manner described on the previous page.

