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Geometric Elements Relative to the Projection Planes by Rotating Them

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Abstract. *Transform the drawing of the general position line so that, relative to the new projection plane, the general position line occupies the position of the level line.*

Keywords: *projection, frontal, horizontal, line, plane, parallel, perpendicular.*

A new projection of a straight line corresponding to the task can be built on a new projection plane P4, placing it parallel to the straightest and perpendicular to one of the main projection planes, i.e. from the plane system P1┴P2 to the system P4┴P1 or P4┴P2. In the drawing, the main axis of the projections should be parallel to one of the main projections of the straight line. An image of the straight line l (A, B) of the general position in the system of planes P1┴P4 is constructed, and P4║l . The new communication lines A1 A4 and B1 B4 are drawn perpendicular to the main axis P1/P4, parallel to the horizontal projection l1.

The new projection of the straight line gives the true value A1 B4 of the segment AB and allows you to determine the slope of the straight line to the horizontal plane of the projections (α=l1N1). The angle of inclination of the straight line to the frontal plane of projections (β=l1P2) can be determined by constructing an image of the straight line on another additional plane P4┴P2 .

I. Transform the drawing of the level line so that it occupies a projecting position relative to the new projection plane.

In order for the image of a straight line to be a point on the new projection plane, the new projection plane must be positioned perpendicular to this level line. The horizontal will have as its projection a point on the plane P4┴P1, and the frontal f – on P4┴P2.

If you want to build a point-degenerate projection of a straight line l of a general position, then two consecutive substitutions of the projection planes will be required to transform the drawing. The straight line l is transformed into the original drawing as follows: first, an image of a straight line is constructed on the plane P4┴P2, located parallel to the straight line itself. In the plane system P2┴P4, the straight line took the position of the level line. Then, from the P2┴P4 system, a transition was made to the P4┴P5 system, with the second new projection plane P5 perpendicular to the straightest l. Since the points A and B of the straight line are at the same distance from the plane P4, then on the plane P5 we get an image of the straight line in the form of a point (A5≡B5≡l5).

II. Transform the drawing of the general position plane so that it occupies a projecting position relative to the new plane.

To solve this problem, the new projection plane must be positioned perpendicular to this plane of general position and perpendicular to one of the main projection planes. This can be done if we take into account that the direction of orthogonal projection onto the new projection plane must coincide with the direction of the corresponding level lines of this plane of general position. Then all the lines of this level on the new plane of the projection plane will be represented by points, which will give a "degenerate" into a direct projection of the plane.

The construction of a new image of the plane Θ (ABC) in the system of planes P4⊥P1 is given. to do this, a horizontal h is constructed in the plane Θ and a new projection plane P4 is located perpendicular to the horizontal h. The graphical solution of the third initial problem leads to the construction of an image of the plane in the form of a straight line, the angle of inclination of which to the new axis of projections P1/P4 determines the angle of inclination α to the plane Θ to the horizontal plane of projections.

By constructing an image of the plane of the general position in the system P2⊥P4 (P4 is positioned perpendicular to the frontal plane), it is possible to determine the angle of inclination β of this plane to the frontal plane of projections.

III. transform the drawing of the projecting plane so that it occupies the position of the level plane relative to the new plane.

Solving this problem allows you to determine the values of flat shapes.

The new projection plane must be positioned parallel to the specified plane. If the initial position of the plane was frontally projecting, then a new image is built in the P2⊥P4 system, and if horizontally projecting, then in the P1⊥P4 system. the new projection axis will be located parallel to the degenerate projection of the projecting plane. A new projection A4B4C4 of the horizontally projecting plane Σ (ABC) on the plane P4⊥P1 is constructed.

If the plane occupies a general position in the initial position, and it is necessary to obtain an image of it as a plane of the level, then resort to double replacement of the projection planes, solving problem III sequentially, and then problem IV. With the first replacement, the plane becomes a projecting one, and with the second, a level plane.

The horizontal h is drawn in the plane λ (DEF). The first axis P1/P4⊥h1 is drawn with respect to the horizontal. The second new projection axis is drawn parallel to the degenerate projection of the plane, and the new communication lines are perpendicular to the degenerate projection of the plane. Distances for constructing projections of points on the P5 plane must be measured on the P1 plane from the P1/P4 axis and postponed along new communication lines from the new P4/P5 axis. The D5E5F5 projection of the DEF triangle is congruent to the DEF triangle itself.

The essence of this method lies in the fact that, with the fixed position of the main projection planes, the position of the specified geometric elements relative to the projection planes changes by rotating them around some axis until these elements occupy a particular position in the original plane system.

As axes of rotation, it is most convenient to choose projecting lines or straight lines of the level, then the points will rotate in planes parallel or perpendicular to the planes of projections.

When rotating horizontally around the projecting line i, the horizontal projection A1 of point A moves along a circle, and the frontal A2 moves along a straight line perpendicular to the frontal projection of the axis, which is the frontal projection of the plane of rotation G2. At the same time, the distance between the horizontal projections of two points A and B remains unchanged when they are rotated by the same angle ω.

Similar conclusions can be drawn for rotation around the frontal projection line. When a flat figure rotates around an axis perpendicular to the projection plane, its projections onto this plane do not change either in magnitude or shape, since the slope of the flat figure to this projection plane does not change, but only the position of this projection relative to the communication lines changes. The second projection on a plane parallel to the axis of rotation varies both in shape and magnitude. The projections of the points on this projection plane are on straight lines perpendicular to the original communication lines. Using these properties, you can use the rotation method to form a drawing, without specifying the image of the axis of rotation and without setting the value of the radius of rotation. This is a method of plane–parallel movement, in which all points of a geometric figure move in mutually parallel planes without changing the actual appearance and dimensions of this figure.

The ABC triangle occupies a common position. By the first plane-parallel transformation, it is placed in a frontal projecting position using the horizontal h, which is positioned as a frontal projecting line in its plane of rotation G‖N1.

By the second movement, the triangle ABC is located parallel to the plane P1. Has the degenerate frontal projection of the triangle remained unchanged (A2B2C2=(A2'V2'C2')? And a new horizontal projection, giving the true value of the ABC triangle, was obtained by constructing new horizontal projections of points A1'V1'C1' as a result of their rotation in parallel frontal planes of the level.

Using this example, the solution of the third and fourth initial problems is considered by converting a complex drawing of a plane of general position by the method of plane parallel displacement.

If we take the level line as the axis of rotation, then the true value of the flat figure of the general position can be built with one turn, i.e. avoid double transformation of the drawing, which took place in the replacement of projection planes and plane-parallel displacement. An image of the triangle ABC (A1B1C1) is constructed after turning it around the horizontal h(C, 1) to a position aligned with the horizontal plane of the level H. Since the horizontal passes through point C, the latter is stationary when the triangle rotates. It is necessary to rotate only points A and B around the horizontal until they align with the plane G‖P1. Point A rotates in a horizontally projecting plane ∑A perpendicular to the axis of rotation. The center of rotation of point A lies on the axis of rotation. At the moment when, as a result of rotation, point A turns out to be in the plane D, i.e. to align with the horizontal plane of the level, its horizontal projection A1 will be removed from the horizontal axis of rotation h1 by a distance equal to the true value of the radius of rotation RA of point A. The full–size RA can be constructed as the hypotenuse O1A of a right-angled triangle, one leg of which is the horizontal projection of radius A1O1, and the second is the height difference of points A and O. Having built a combined horizontal projection of point A, it is easy to complete the image of the entire triangle A1B1C1 in a position combined with the plane D, using a fixed point 1 and the plane of rotation of point B (∑B1⊥h1). The frontal projection of the triangle ABC degenerates into a straight line and aligns with the projection G2 of the alignment plane.

Similar actions are performed when rotating a flat shape around its front. In this case, the alignment is carried out with the frontal plane of the level (F‖P2) passing through the axis of rotation – the frontal.

Solving simple tasks in a complex drawing is greatly simplified if the space elements of interest occupy a particular position, i.e. they are located parallel or perpendicular to the projection planes. The resulting "degenerate" projections help to get an answer to the task at hand or simplify the course of its solution. To achieve such a position of geometric elements, a complex drawing is transformed or rebuilt based on specific conditions. The transformation of the drawing shows a change in the position of geometric images or projection planes in space. There are basically two ways to transform a drawing: the method of replacing projection planes and the method of rotation.

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