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Hidden lines

↳ in **drafting** in **Systems of representation**

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Also known as: draughting, engineering drawing, engineering graphics

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Last Updated: Sep. 11, 2025 • [Article History](#)

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It is standard practice to use dashes to represent any line of an object that is [hidden](#) from view. A drafter—in deciding whether a line in a view should be represented as hidden or as visible—relies on the fact that in third-angle projection the near side of the object is near the [adjacent](#) view, but in first-angle projection the near side of the object is remote from the adjacent view. In [Figure 4B](#) (third-angle projection) the top of the front view is near the top view; the front of the top view is near the front view; and the front of the side view is near the front view. In first-angle projection, however, the top of the front view is remote from the top view; the front of the top view is remote from the front view, and the

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remote in an adjacent view cannot hide what is near in that view.

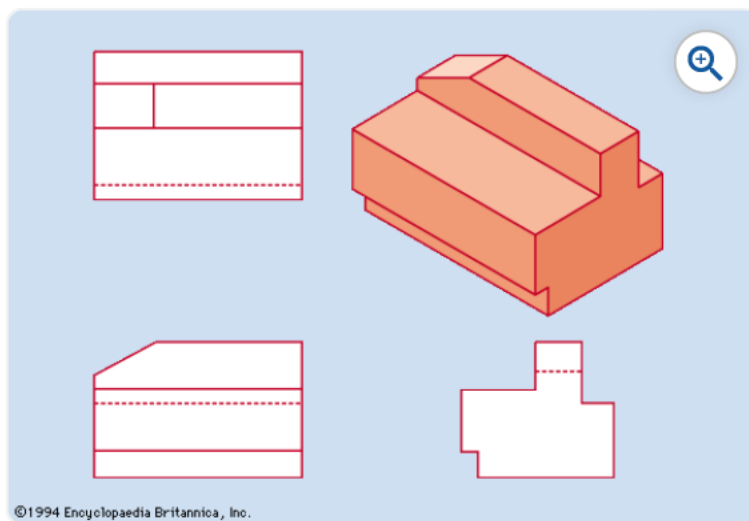
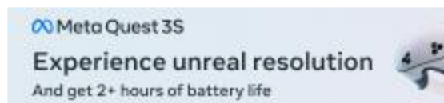


Figure 5: Use of dashed lines to represent edges hidden in views of a complicated object.

Figure 5 shows a pictorial representation of an object and the third-angle [projections](#) of that object. The arrangement of the three views gives intuitive reinforcement to the correct selection of the line shown as hidden in each view because it is blocked by portions of the object that are nearer in the adjacent views.

The number of hidden lines in a view of a complicated object may be very great. For purposes of studying visibility, the direction of projection may be thought of as always vertically downward for a top view, always horizontally from front to back for a front view, and always horizontally right-to-left for a right-side view.

In [Figure 5](#) the hidden lines in the views could be identified by visualizing the object, a process that can be quite difficult for complicated objects. The following basic principle of [descriptive](#) geometry is useful in analyzing such a problem:



I. If any point is projected orthogonally onto each of two perpendicular planes and the planes are rotated into coincidence about their line of intersection, then the projections of the

point on the two planes will lie on a straight line perpendicular to the line of intersection.

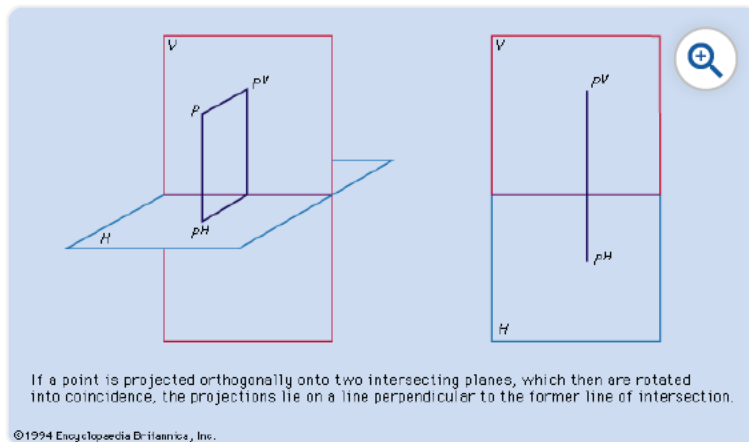


Figure 6: Descriptive geometry, principle I (see text).

Figure 6 demonstrates this statement.

Although the ground line, or line of intersection of H and V , is seldom drawn in the representations of front and top or of front, top, and side views of objects, it is understood to be horizontal. Thus for any point P , P^H and P^V lie on a vertical line of the [drawing](#).

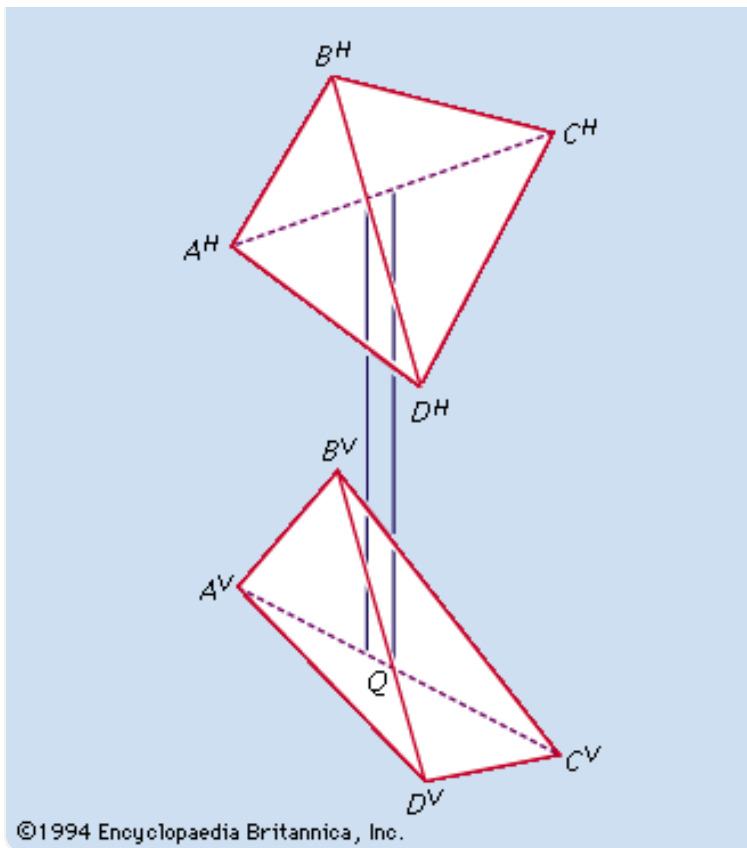


Figure 7: Identification of the hidden edge in third-angle projections of a tetrahedron (see text).

A tetrahedron (triangular pyramid) with vertices A , B , C , and D is shown in third-angle projection in [Figure 7](#). The edges AC and BD do not intersect, although their projections do. To determine which of these two edges is visible in the top view, the drafter considers location M , where the H projection of a point on AC and the H projection of a point on BD coincide. By principle I the V projections of these two points will lie on a vertical line from the crossing of $A^H C^H$ and $B^H D^H$. A vertical construction line in [Figure 7](#) indicates that the point on BD is nearer to the top of the tetrahedron than the point on AC . This means that BD crosses above AC , so that BD must be visible in the top view and AC hidden. Similarly, to study the visibility of these lines in

the front view, the vertical construction line is drawn through Q , the crossing of $A^V C^V$ and $B^V D^V$; this procedure indicates that the point on BD is nearer to the front of the tetrahedron than the point on AC . Thus BD crosses in front of AC , so that BD is visible in the front view and AC is hidden.

Auxiliary views

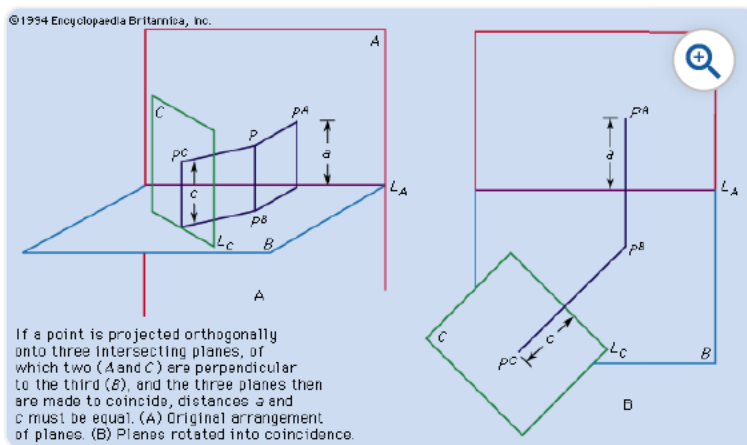


Figure 8: Descriptive geometry, principle II (see text).

Figure 8 illustrates another basic principle of descriptive geometry that facilitates the

discussion of [auxiliary views](#):



II. Given two planes (A and C) perpendicular to a third plane (B), a point P projected orthogonally onto the three planes, and the rotation of A and C into B about their respective lines of intersection with B (L_A and L_C), then P^A is the same distance from L_A as P^C is from L_C .

To convey complete and correct information many views may be necessary to show every plane surface bounding the object in its true size and shape at least once. In choosing the principal views, the drafter positions the object with reference to H and V so as to have the maximum number of its surfaces parallel to H or V or R , a third plane perpendicular to both H and V . Orthographic projection yields the true size and shape of every such surface in the front, the top, or the side view. A surface

parallel to H or V or R , the three principal planes, is perpendicular to the other two. Additional or [auxiliary](#) views are necessary to represent the true size and shape of other plane surfaces. A plane perpendicular to only one of the three principal planes is said to be in an inclined position; a plane not perpendicular to any of the principal planes is said to be in an oblique position.

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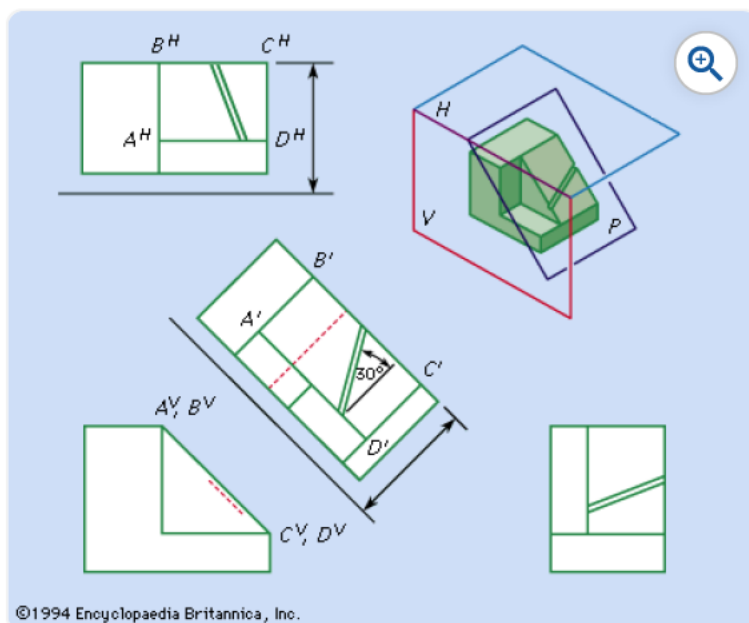
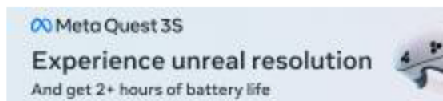


Figure 9: Use of auxiliary view to show true size and shape of an inclined surface (*ABCD*), which is not correctly represented in the front, top, or side view...(more)

Figure 9 illustrates the application of principle II to represent the true size and shape of an inclined surface. The groove in surface *ABCD* makes an angle of 30° with a line (not shown) parallel to the edge *DC*. An auxiliary view in which *A*, *B*, *C*, and *D* are labeled with primes, obtained by [projection](#) onto a plane *P*, parallel to the surface *ABCD*, is the only one in which the true shape of *ABCD* and the true size of the 30° angle are correctly shown. The dimension indicated by the double-headed arrow is the same in the *H* (top) and auxiliary views, as required by principle II. The plane of the auxiliary view and the plane of the *H* view are perpendicular to the plane of the *V* view.

The true shape of an oblique surface can be shown correctly only on a second auxiliary view prepared by an extension of the procedure used for a first auxiliary view.

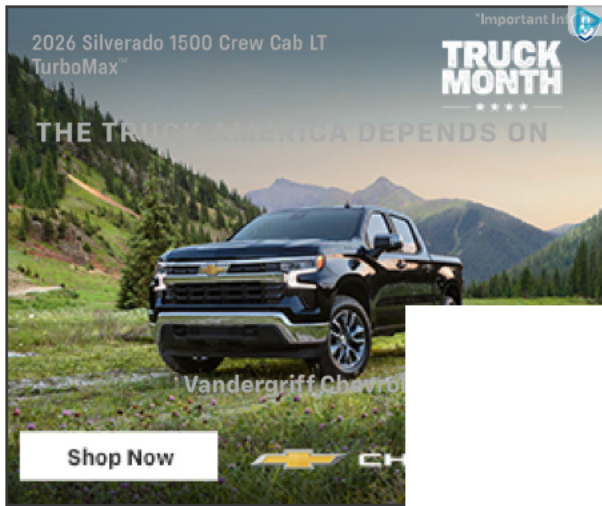


Automobile bodies, aircraft and ship hulls, and the irregular terrain of the natural site of a dam, bridge, or highway, are studied and detailed by means of [contour lines](#) on the surfaces. Three-dimensional modeling is necessary if design is highly competitive, as with automobiles, or if optimum streamlining is essential. [Contour](#) lines are projections of the intersections of the surface under study and imaginary planes at the reference locations.

Pictorial views

Although the emphasis on true descriptions of sizes and shapes requires [orthographic projection](#) for working and construction drawings, pictorial representations may be useful. In [architecture](#), for example, the designer of the exterior of a building or the interior of an important space may be guided by [perspective](#) drawings and other pictorial representations. The construction of major projects may be preceded by the building of three-dimensional models, although these are expensive and seldom used in the early stages of design. Pictorial representations often are used for attracting investors or for advertising of new buildings and other products. Although a specialist in marketing might be intimidated by working drawings, he might grasp a pictorial representation easily enough to make

useful suggestions about a design before production or construction was under way.



The execution of a perspective [drawing](#) may require more time than is justified in the design of a small item. In many cases orthographic projection, coupled with the rotation of the object with respect to the reference planes, produces an adequate pictorial representation.

[Figures 2A, 2C, 3, 4A, and 5](#) illustrate the pictorial representation achieved by [oblique projection](#), in which the principal surface of the object is considered to be in the plane of the paper and thus is represented in true size and shape. The angle the receding axis makes with the horizontal lines of the drawing is chosen arbitrarily but with care in terms of the clarity of the particular representation. True lengths are set off along the receding axis as an

[arbitrary](#) choice. This is a convenient method for constructing a pictorial representation.

Unacceptable distortion results when oblique projection is used to represent large objects or those with large dimensions or important details along the receding axis.

Drafting practice

Standards

The value of a set of drawings conveying the complete and correct information necessary for the execution of a project fostered the gradual [standardization](#) of practices. The widespread use of both first-angle and third-angle projection was long a major problem, but around the beginning of the 19th century a third-angle projection became the standard practice in the execution of industrial drawings in the [United States](#). Australia followed this lead, but most industrial countries continued to follow Great Britain's use of first-angle projection. Architects in the United States and elsewhere generally use first-angle projection.

Drafting standards commonly evolve as a [consensus](#) develops among professional practitioners. Since 1917 in the United States the [American National Standards Institute](#) and its predecessors have encouraged this process and published standards for projections, various types of sections, dimensioning and tolerancing, representation of screw threads, all types of fasteners, graphic symbols for various specialties, and a great deal more. In other industrialized nations, [analogous](#) organizations—such as the British Standards Institution and the Deutsches Institut für Normung (“German Standards Institute”)—function in the same way. In addition, many industrial groups and individual companies have established more detailed standards for their particular purposes.

The [International Organization for Standardization](#), with headquarters in Geneva, coordinates global standards. International [communication](#) is hindered by the lack of agreement concerning first-angle versus third-

angle projection and by the persistence in the United States of inches, feet, and other customary units for dimensioning. Economic pressures, however, are moving American industries to adopt the international [metric system](#), [SI](#) units (Système Internationale d'Unités). The delay is related to the substantial costs of retooling and retraining. Because the strategy for correctly dimensioning a [drawing](#) is the same for all units, the rate of transition to SI units in the United States is not related to the drafting [community](#), nor are SI units a special problem in drafting practice.

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Equipment

Correct design information and projection are the [imperatives](#) of a set of engineering drawings. The skill and [dexterity](#) shown by some persons in drawing more accurately, more quickly, or more neatly have recognized value in the preparation of such drawings.

Equipment has been invented to facilitate the performance of the manual tasks. Most widely known are the T square, triangle, protractor, and compass; the parallel straightedge is an alternative to the T square. The drafting machine, introduced about 1930, allows a straightedge to be moved while maintaining any desired angle between it and the edge of the drawing board. Combining the functions of the T square, triangle, protractor, and scale, it greatly increases the efficiency of producing a drawing.

Computers



computer-aided design Three-dimensional components being drawn on a laptop using computer-aided design.

A very important change in drafting procedure began in the early 1960s when programs were introduced to facilitate the composition of graphic images on the screen of a computer monitor, to retain the associated data in memory, and to retrieve the information to actuate plotting devices that produce not only the lines and arcs of an engineering drawing

but also the symbols, dimension arrows, and strings of alphanumeric characters of notes and [legends](#). Software can be prepared or purchased to perform the tasks involved in drafting: sketching of ideas to guide the design; calculation of the sizes of parts to satisfy codes, mechanical properties of materials, and machining requirements; preparation of working drawings; and production of pictorial representations. [Computer-aided](#) design (CAD) may be likened to [word processing](#). Under direction, a [word processor](#) can correct misspellings, insert or delete words or sentences, rearrange sections of an article, or prepare accurately typed copies, but it cannot write an article. Similarly, knowledge, experience, and all but manual drawing skill are needed to produce a set of drawings with CAD, which has become increasingly important in industrial and architectural drafting.



The image is a dark green rectangular advertisement. In the top left corner is the Merck logo, consisting of a stylized 'M' inside a circle followed by the word 'MERCK'. In the top right corner, it says 'PAID FOR BY MERCK'. The main text in the center is 'LDL-C IS A MAJOR CAUSAL RISK FACTOR FOR ASCVD' in large, bold, white capital letters, with 'LDL-C' in pink. Below this text is a white rounded rectangular button with the text 'LEARN MORE' in dark green. At the bottom left, in small white text, it says 'Reference: 1. Martin SS, et al. Circulation. 2025;'. There is a small blue play button icon in the top right corner of the green area.

Duplication of drawings

[Blueprinting](#), the first economical method for duplicating drawings, was invented in 1842 and introduced in the United States in 1876.

The diazo process, [xerography](#), and computer-controlled drafting machines have more recently shared this function. The availability of numerous copies of drawings [facilitated](#) the [division of labour](#) among artisans, who formerly had worked out many details—such as exact sizes and shapes of parts, fits, and clearances—while custom building each item.

The specification of these details became the duty of the designer-drafters, requiring them to refine their skills accordingly and leading to further development of the drafting profession.