Engineering Graphics

Isometric Projections and Isometric Views

5.1 Introduction to Isometric Projections

Isometric projection is a type of pictorial projection used to represent a three-dimensional object in a single two-dimensional drawing, in a manner that conveys a realistic, easily understandable impression of its overall three-dimensional shape. The word "isometric" literally means "equal measure," referring to the defining characteristic of this projection: the three principal axes of the object (conventionally taken along its length, breadth, and height) are drawn equally inclined to one another and to the plane of projection, at an angle of 120° between each pair of axes.

Because all three axes are treated identically (equally foreshortened), an isometric projection preserves the correct proportional relationship between the length, breadth, and height of an object, making it a particularly convenient and widely used method for preparing pictorial (three-dimensional-looking) engineering sketches.

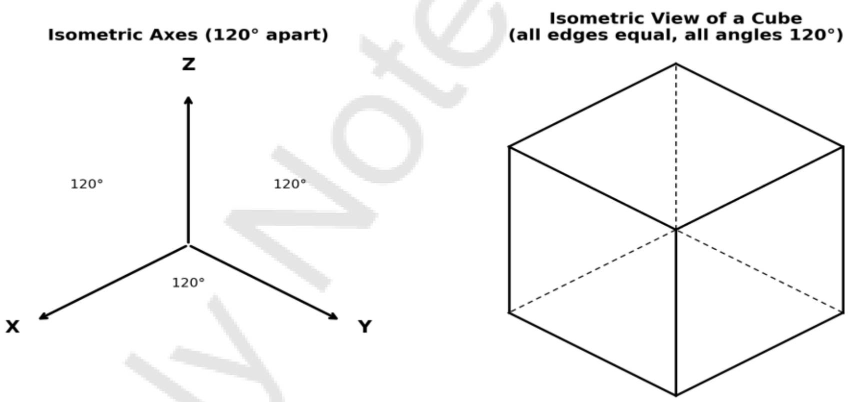

Figure 1: The three isometric axes, drawn at 120° to each other, and an isometric view of a cube

Concept of Isometric Scale

When an object is projected onto a plane in true isometric projection, each of its edges appears foreshortened (reduced in length), since none of the principal faces of the object lie parallel to the plane of projection. Mathematically, it can be shown that every true length, when represented in a correct isometric projection, is reduced by a constant factor of approximately 0.815 (more precisely, $\sqrt{(2/3)}$). This constant ratio is known as the isometric scale.

The isometric scale can be conveniently constructed graphically, without direct calculation, using the method illustrated below: a true-length line is drawn at 45° to a horizontal reference line, and a second line is drawn at 30° to the same horizontal reference line. True lengths are marked off along the 45° line, and vertical projectors are then dropped down to the horizontal line and back up to the 30° line, transferring the correctly reduced (isometric) lengths onto it.

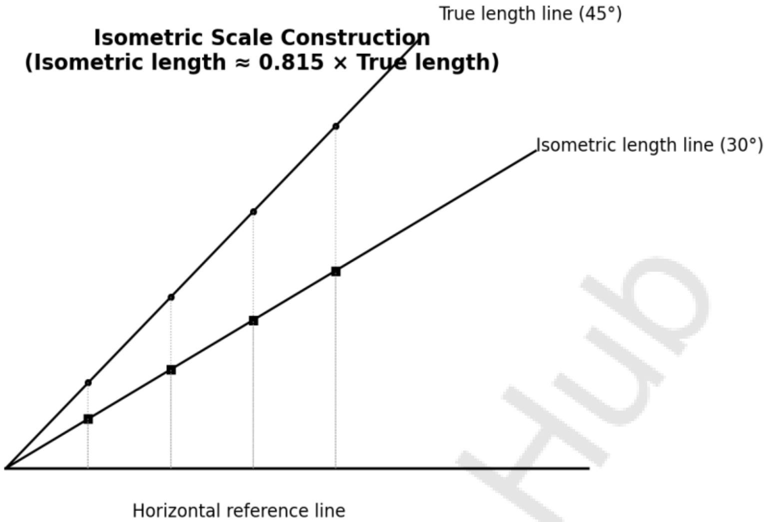

Figure 2: Graphical construction of the isometric scale

Isometric Views

Although a true isometric projection (using the isometric scale) is mathematically correct, constructing an isometric scale for every drawing is time-consuming and not strictly necessary for most practical purposes, since the constant isometric ratio applies uniformly to all dimensions of the object and therefore does not distort its proportions. For this reason, engineering drawings intended purely as pictorial sketches are, in standard practice, almost always prepared as isometric views (also called isometric drawings), in which true (actual) measurements are marked directly along the isometric axes, without applying the isometric scale reduction at all.

The key differences between a true isometric projection and an isometric view are summarised below:

Aspect	Isometric Projection	Isometric View (Isometric Drawing)
Definition	A true, mathematically accurate projection of an object, drawn using the isometric scale, in which all dimensions are foreshortened (reduced) to approximately 0.815 times their true length	A conventional, simplified drawing of an object, drawn using true (actual) measurements directly, without applying the isometric scale reduction
Size Compared to Object	Smaller than the actual object, by a constant factor (≈ 0.815)	Larger than the true isometric projection, by a factor of

		approximately 1.225 (i.e. drawn about 22.5% larger than a true isometric projection, but using true dimensions directly)
Method of Construction	Requires construction of an isometric scale first, then all measurements are marked using this reduced scale	All measurements are marked directly using an ordinary scale, with true (actual) lengths, without any reduction
Practical Use	Used when strict dimensional accuracy of the pictorial drawing itself is required	Used almost universally in practice for pictorial engineering sketches, since it is quicker to construct and the constant enlargement does not affect the proportions or usefulness of the drawing

Since an isometric view is simply enlarged uniformly (by a constant factor of about 1.225) compared to a true isometric projection, it retains exactly the same proportions and overall appearance, and is therefore considered an entirely acceptable and, in practice, preferred substitute for the true isometric projection in the vast majority of engineering drawing applications.

5.2 Conversion of Orthographic Views into Isometric Views: Simple Objects

A common and important exercise in engineering graphics is the conversion of a given set of orthographic views (typically the front view and top view) of a simple solid into its corresponding isometric view. This section illustrates this conversion process for four common regular solids: a square prism, a square pyramid, a cylinder, and a cone.

The general procedure for this conversion involves the following steps:

1. Study the given orthographic views (front view and top view) carefully, to understand the true shape and dimensions of the object.
2. Draw the isometric axes, and mark the position of the base (or a suitable reference face) of the object along two of these axes, using true measurements (for an isometric view).
3. Construct the base of the object in isometric form: straight-sided bases (such as squares) are drawn as parallelogram-like shapes with true edge lengths, while circular bases are drawn as ellipses.

4. Project the height of the object vertically upward (parallel to the vertical isometric axis) by the true height, to locate the top face, apex, or top circular face, as appropriate for the particular solid.
5. Complete the isometric view by joining the corresponding points with straight lines (for prisms and pyramids) or smooth curves (for the elliptical faces of cylinders and cones), applying correct visible and hidden line conventions throughout.

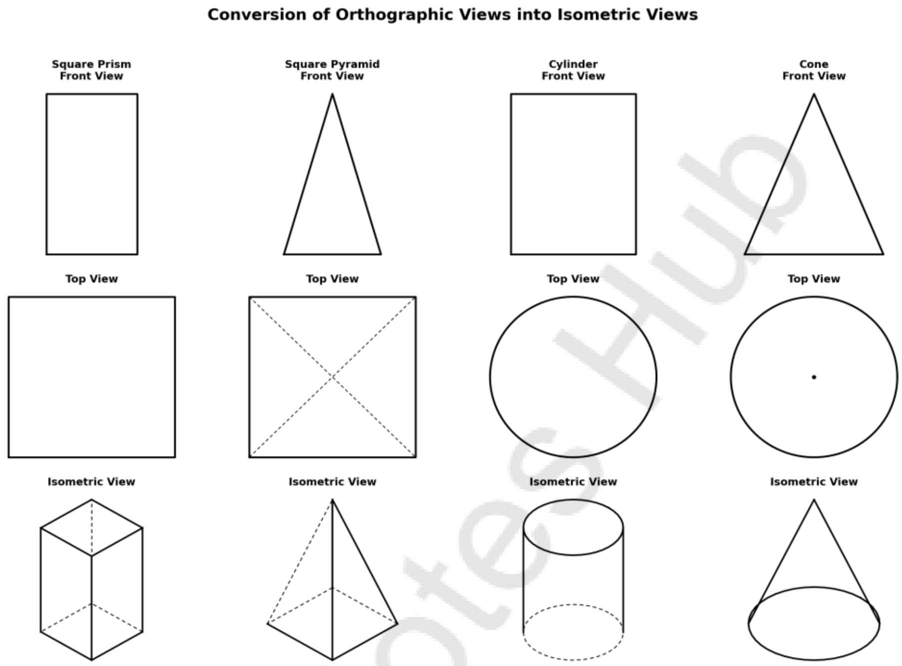

Figure 3: Conversion of the front view and top view into the isometric view, for a square prism, square pyramid, cylinder, and cone

As illustrated in Figure 3, several important points apply consistently across all four solids:

- The square base of the prism and pyramid, when drawn in isometric, is no longer shown as a right-angled square (as in the true-shape top view), but as a parallelogram-like shape, since the base now lies in an isometric plane inclined to the plane of the paper; however, all four sides remain equal in length, matching the true dimensions of the square.
- The circular base of the cylinder and cone, when drawn in isometric, is represented as an ellipse, since a circle viewed from an oblique angle always appears foreshortened into an elliptical shape; the cylinder requires two such ellipses (top and bottom), offset vertically by the true height of the cylinder, while the cone requires only one base ellipse, together with the apex point located centrally above it.
- Vertical edges and axes of each solid (parallel to the vertical isometric axis) remain vertical, straight lines in the isometric view, drawn to their true length (in an isometric view).

- Edges or surfaces of the object that would not be visible from the chosen isometric viewing direction are represented using dashed (hidden) lines, exactly as in orthographic projection.

Mastery of this conversion process for simple solids such as prisms, pyramids, cylinders, and cones provides the essential foundation for tackling the isometric representation of more complex composite objects, encountered in more advanced engineering graphics work.

2. Multiple Choice Questions (MCQs)

Answer the following questions by selecting the most appropriate option.

1. Isometric projection is a type of pictorial projection in which the three principal axes of an object are:

A) All parallel to one another
B) Equally inclined to the plane of projection, at 120° to each other
C) Perpendicular to each other in the drawing
D) Randomly oriented

2. In an isometric projection, the three isometric axes are drawn at an angle of:

A) 90° to each other
B) 120° to each other
C) 60° to each other
D) 45° to each other

3. The isometric scale is used to convert:

A) True lengths into isometric (foreshortened) lengths
B) Isometric lengths into orthographic views directly
C) Angles into lengths
D) Colours into shading

4. The ratio of isometric length to true length, as given by the isometric scale, is approximately:

A) 1.225
B) 0.815
C) 1.000
D) 0.500

5. An isometric view (isometric drawing), as commonly used in practice, differs from a true isometric projection in that it is:

A) Drawn using the isometric scale, exactly like a true projection
B) Drawn using true (actual) measurements directly, without applying the isometric scale reduction

C) Always smaller than a true isometric projection

D) Never used in engineering practice

6. Compared to a true isometric projection, an isometric view (drawn with true measurements) is:

A) Exactly the same size

B) Approximately 22.5% larger

C) Approximately 22.5% smaller

D) Always drawn to a random, unrelated size

7. A circle lying in a plane parallel to one of the principal faces of a cube, when drawn in isometric view, appears as:

A) A perfect circle of the same diameter

B) An ellipse

C) A straight line

D) A square

8. When converting orthographic views of a square prism into an isometric view, the square cross-section, if lying in a plane containing two isometric axes, is drawn as:

A) A circle

B) A parallelogram (rhombus-like shape), with sides equal to the true length of the square's sides

C) A perfect right-angled square, unchanged

D) A single straight line

9. When converting the orthographic views of a cone into its isometric view, the circular base of the cone is represented as:

A) A perfect circle

B) An ellipse

C) A triangle

D) A straight line

10. In the isometric view of a cylinder, the top and bottom circular faces are represented as:

A) Two straight lines

B) Two ellipses of the same size, offset vertically by the height of the cylinder

C) A single ellipse only

D) Two different-sized circles

11. Vertical edges of an object (parallel to the vertical isometric axis) are drawn in an isometric view as:

A) Inclined lines

B) Vertical straight lines, of true length (if isometric view) or reduced length (if true isometric projection)

C) Curved lines

D) Horizontal lines

12. When converting the front view and top view of a square pyramid into an isometric view, the apex of the pyramid is located by:

A) Guessing its position

B) Locating the centre of the base in isometric, and marking the true height vertically upward from it

C) Placing it at a random point unrelated to the base

D) Ignoring the height of the pyramid entirely

13. Hidden edges in an isometric view of a solid object are represented using:

A) Continuous thick lines

B) Dashed (hidden) lines, as in orthographic views

C) No line at all

D) Centre lines

14. In most practical engineering sketches and textbooks, isometric drawings are generally prepared as:

A) True isometric projections, using the isometric scale

B) Isometric views, using true (actual) measurements directly

C) Neither, since isometric drawing is never used practically

D) Always to a random scale

15. The starting point for converting orthographic views into an isometric view is generally to:

A) Draw the isometric axes and locate the base (or a reference face) of the object along them

B) Draw the object randomly, without reference to any axes

C) Skip the orthographic views entirely

D) Begin with the smallest feature of the object only

Answer Key

1. B) Equally inclined to the plane of projection, at 120° to each other | 2. B) 120° to each other | 3. A) True lengths into isometric (foreshortened) lengths | 4. B) 0.815 | 5. B) Drawn using true (actual) measurements directly, without applying the isometric scale reduction | 6. B) Approximately 22.5% larger | 7. B) An ellipse | 8. B) A parallelogram (rhombus-like shape), with sides equal to the true length of the square's sides | 9. B) An ellipse | 10. B) Two ellipses of the same size, offset vertically by the height of the cylinder | 11. B) Vertical straight lines, of true length (if isometric view) or reduced length (if true isometric projection) | 12. B) Locating the centre of the base in isometric, and marking the true height vertically upward from it | 13. B) Dashed (hidden) lines, as in orthographic views | 14. B) Isometric views, using true (actual) measurements directly |

15. A) Draw the isometric axes and locate the base (or a reference face) of the object along them

3. Broad / Long Answer and Practical Questions

1. Define isometric projection, and explain the significance of the three isometric axes being equally inclined at 120° to each other.

2. Explain the concept of an isometric scale, and describe, with the help of a diagram, the construction method used to derive isometric lengths from true lengths.

3. Distinguish between isometric projection and isometric view (isometric drawing), explaining the practical reason why isometric views (using true measurements) are more commonly used than true isometric projections in everyday engineering practice.

4. Explain why a circular face of an object, such as the base of a cylinder or cone, is represented as an ellipse rather than a circle in an isometric view.

5. Describe the general procedure used to convert the orthographic views (front view and top view) of a simple solid into its isometric view.

6. Referring to the illustrations in this chapter, describe how the orthographic views of a square prism are converted into its isometric view.

7. Referring to the illustrations in this chapter, describe how the orthographic views of a square pyramid are converted into its isometric view, explaining how the position of the apex is determined.

8. Referring to the illustrations in this chapter, describe how the orthographic views of a cylinder are converted into its isometric view, explaining how the top and bottom circular faces are represented.

9. Given the front view and top view of a cone of base diameter 50 mm and height 70 mm, draw its isometric view (using true measurements, i.e. as an isometric view rather than a true isometric projection).

10. Given the front view and top view of a square prism of base side 40 mm and height 80 mm, draw its isometric view, clearly showing any hidden edges using the appropriate line convention.