# IE 111 Computer Aided Engineering Drawing 

# Orthographic Projection - Visualizing Solids and Multiview Drawings 

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## Visualizing Solids and Multiview Drawings - Illustrative Examples



## Visualizing Solids and Multiview Drawings - Illustrative Examples



## Visualizing Solids and Multiview Drawings - Illustrative Examples

## Rule for Alignment of Features

Every point or feature in one view must be aligned on a parallel projectior in any adjacent view.

## Rule for Distances in Related Views

Distances between any two points of a feature in related views must be equal.


## Fundamental Views of Edges for Visualization

## Fundamental Views of Edges

Determine the fundamental views of edges on a multiview drawing by the position of the object relative to the current line of sight and the relationship of the object to the planes of the glass box.

Rule for True Length and Size Features are true length or true size when the lines of sight are perpendicular to the feature.


TOP

Rule for Foreshortening Features are foreshortened when the lines of sight are not perpendicular to the feature.


FRONT


RIGHT SIDE

## Fundamental Views of Edges for Visualization

## Oblique Line

Oblique line $1-2$ is not parallel to any of the principal planes of the projection of the glass box.


## Fundamental Views of Principal Planes for Visualization

## Normal Faces

Projection of the normal faces onto the image plane.

(C)

## Fundamental Views of Principal Planes for Visualization

## Normal Face Projection

A normal face projects on all three principal image planes. On the image plane, the face appears true size and shape. In the other two, the face appears on edge and is represented as a line.


## Fundamental Views of Principal Planes for Visualization

## Edge Views of a Normal Face

In amultiview projection, edge views of a normal face become the outlines of nother face.


## Fundamental Views of Principal Planes for Visualization

## Camera Metaphor

The metaphor of cameras can be used to describe capturing three principal views of the object front, top, and right side - through the three image planes.


## Fundamental Views of Inclined Planes for Visualization

## Inclined Face Projection

An inclined face is oriented so that it is not parallel to any of the principal image planes. The inclined face is foreshortened in two views and is an edge in one view.


(A)

(C)
C)
(D)

## Fundamental Views of Inclined Planes for Visualization

## Oblique Face Projection

The projection of an oblique face is foreshortened in all three principal image planes.

(A)

(B)

## Fundamental Views of Surfaces for Visualization

## Fundamental Views of Surfaces



Surface A is parallel to the frontal plane of projection. Surface C is parallel to the profile plane of projection. Surface D is an inclined plane and is on edge in one of the principal views (the front view). Surface E is an oblique plane and is neither parallel nor on edge in any of the principal planes of projection.

## Multiview Drawings of Solid Primitive Shapes



Understanding and recognizing these shapes will help you to understand their application in technical drawings. Notice that the cone, sphere, and cylinder are represented with fewer than three views.

## Multiview Drawings of Solid Primitive Shapes



## Multiview Drawings of Solid Primitive Shapes

## Rule of Configuration of Planes

Surface B is an example of the Rule of Configuration of Planes. The edges of surface C, 3-4 and 5-6, are examples of the Rule of Parallel Features.

## Rule for Configuration of

 PlanesAreas that are the same feature will always be similar in configuration from one view to the next, unless viewed on page.

viewed on page.

Rule for Parallel Features Parallel features will always appear parallel in all viewes.


## Fundamental Views of Surfaces for Visualization

## Rule for Edge Views

Surfaces that are parallel to the lines of sight will appear on edge and be represented as lines.




FRONT


RIGHT SIDE

## Fundamental Views of Surfaces for Visualization

## Angles

Angles other than 90 degrees only can be measured in views where the surface that contains the angle is perpendicular to the line of sight. A 90degree angle can be measured in a foreshortened surface if one edge is true length.


## Fundamental Views of Curved Surfaces for Visualization

## Limiting Elements



Cone


Cylinder

In technical drawings, a cone is represented as a circle in one view and a triangle in the other. The sides of the triangle represent limiting elements of the cone. A cylinder is represented as a circle in one view and a rectangle in the other.

## Fundamental Views of Curved Surfaces for Visualization

## Tangent Partial Cylinder



A rounded end (or partial cylinder) is represented as an arc when the line of sight is parallel to the axis of the partial cylinder. No line is drawn at the place where the partial cylinder becomes tangent to another feature, such as the vertical face of the slide.

## Fundamental Views of Curved Surfaces for Visualization

## Nontangent Partial Cylinder



When the transition of a rounded end to another feature is not tangent, a line is used at the point of intersection.

## Fundamental Views of Curved Surfaces for Visualization

## Elliptical Representation of a Circle

An elliptical view of a circle is created when the circle is viewed at an oblique angle.


Cylinder viewed at $90^{\circ}$ to its top surface

Cylinder viewed at $45^{\circ}$ to its top surface

## Fundamental Views of Curved Surfaces for Visualization

## Viewing Angles for Ellipses

The size or exposure of an ellipse is determined by the angle of the line of sight relative to the circle.

(A) What you see: TRUE SIZE

(C) What you see: ELLIPSE

(B) What you see: ELLIPSE

(D) What you see: ELLIPSE

## Fundamental Views of Curved Surfaces for Visualization

## Representation of Various Types of Machined Holes


(A) Through hole

(Drill diameter) $82^{\circ}$ (Countersink diameter an angle drawn at $90^{\circ}$ )


## Fundamental Views of Curved Surfaces for Visualization

## Representation of Various Types of Machined Holes


(D) Drilled and countersunk hole

(E) Drilled and spotfaced hole

(F) Threaded hole


## Fundamental Views of Curved Surfaces for Visualization

## Representation of Fillets and Rounds

Fillets and rounds indicate that surfaces of metal objects have not been machine finished; therefore, there are rounded corbers.


## Fundamental Views of Fillets and Rounds for Visualization

## Representing Filleted and Rounded Corners

Lines tangent to a fillet or rounded are constructed and then extended, to create a sharp corner. The location of sharp corner is projected to the adjacent view, to determine where to place representative lines indicating a change of planes.


## Fundamental Views of Fillets and Rounds for Visualization

## Examples of Representing Filleted and Rounded Corners

Lines are added to parts with fillets and rounds, for clarity. Lines are used in the top views of these parts to represent changes of planes that have fillets or rounds at the corners.


## Fundamental Views of Chamfers for Visualization

## Examples of Internal and External Chamfers

Chamfers are used to break sharp corners on ends of cylinders and holes.


Internal Chamfer

## Fundamental Views of Runouts for Visualization

## Runouts



Runouts are used to represent corners with fillets that intersect cylinders. Notice the difference in the point of tangency with and without the fillets.

## Fundamental Views of Runouts for Visualization

## Examples of Runouts in Multiview Drawings


(A)

(B)

(C)

(D)

## Fundamental Views of Runouts for Visualization

## Examples of Runouts in Multiview Drawings



## Fundamental Views of Runouts for Visualization

## Examples of Runouts in Multiview Drawings



## Fundamental Views of Runouts for Visualization

## Representing the Intersection of Two Cylinders



(B)

(C)

Representation of the intersection of two cylinders varies according to the relative sizes of the cylinders.

## Fundamental Views of Runouts for Visualization

## Representing the Intersection Between a Cylinder and a Hole



Representation of the intersection between a cylinder and a hole or slot depends on the size of the hole or slot relative to the cylinder.

## Revolution Conventions

## Revolution Conventions Used to Simplfy the Representation of Ribs and Webs



(A) True projection

(B) Preferred

## Revolution Conventions

Revolution Conventions Used on Objects with Bolt Circles to Eliminate Hidden Lines and Improve Visualization


## Revolution Conventions

## Revolution Conventions Used to Simplfy the Representation of Arms




True projection


Preferred

## Visualization for Design

## Design Visualization


(© Art Resource.)
Leonardo da Vinci used drawings as a means of visualizing his designs.

## Visualization for Design

## Hand/Eye Connection



The hand/eye connection is important when sketching.

## Visualization for Design

## Hand/Eye/Mind Connection



The hand/eye/mind connection more accurately describe the processes used to make sketches. The mind forms a mental picture of existing or nonexisting objects, which can then be sketched. The feedback loop between the mind and the hand is so powerful that the object need not exist.

## Solid Object Features



These rectangular prism and cylinder primitives show important features: edge, face, vertex, and limiting element.

## Solid Object Features

## Object Faces



The hexagonal prism has an end face attached to six other faces.

## Solid Object Visualization

## Combinations and Negative Solids


(A)

(B)

(C) No!

## Combining Solid Objects

Additive combinations of primitives can be used to create new forms. This example shows acceptable (A and B) and unacceptable © ways a cylinder could be added to a cube to form a new object.

## Solid Object Visualization

## Combinations and Negative Solids



## Removing Solid Objects

The cylinder subtracted from the cube is equal volume and shape to the hole left in the cube.

## Solid Object Visualization

## Combinations and Negative Solids



## Subtracting a Square Prism

When a square prism is subtarcted from the cube, the edges of the hole match the end face of the square prism.

## Solid Object Visualization

## Combinations and Negative Solids



## Subtracting Progressively Larger Prisms

Subtraction of progressively larger prisms from the brick creates entirely different geometric forms.

## Solid Object Visualization

## Combinations and Negative Solids



## Subtracting Progressively Larger Wedges

Subtraction of progressively larger wedges from the brick creates new geometric forms.

## Solid Object Visualization

## Combinations and Negative Solids



Subtraction of progressively larger pyramids from the brick creates new geometric forms.

## Solid Object Visualization

## Combinations and Negative Solids


(A)

(B)

Additive and Subtractive techniques can be used to make a solid geometric form.

## Solid Object Visualization

## Planar Surfaces



## Normal Cutting Plane

A normal cutting plane in the brick will create a new surface called face. This new surface is exactly the same as the end face.

## Solid Object Visualization

## Planar Surfaces



## Cutting Plane Rotated About Single Axis

A cutting plane is rotated about a single axis in the brick. This creates inclined faces until the plane has rotated 90 degrees, creating a face normal to the top view.

## Solid Object Visualization

## Planar Surfaces



## Cutting Plane Rotated About Two Axes

Rotating a cutting plane about two axes in the brick creates a new face called an oblique faces.

## Solid Object Visualization

## Planar Surfaces



Cutting Plane Rotation


Rotating a cutting plane in a cylinder creates circular and elliptical faces.

## Solid Object Visualization

## Planar Surfaces


(A)

(B)

(C)


Progressive Slicing of a Cylinder, Cone, and Sphere primitives.

## Solid Object Visualization

## Symmetry


(A)

(B)

## Planes of Symmetry

Planes of symmetry for a cylinder are created by passing a plane through the midpoint of the cylinder (A) or by passing the plane through the centers of the circular ends (B).

## Solid Object Visualization

## Surface Models (Developments)



## Surface Cutting Planes


(B)

Cutting planes can be used to cover the surface of the brick.

## Solid Object Visualization

## Surface Models (Developments)



## Development

Development of the brick is accomplished by cutting the skin of the brick along some of the edges, then unfolding the skin and flattening it.

## Solid Object Visualization

## Surface Models (Developments)



Brick edges that are attached to form the brick skin are indicated by dashed lines.


There are many alternative methods of creating the development for the brick, such as the one shown here.

## Solid Object Visualization

## Surface Models (Developments)


(A)

(B)

## Single- and Double-Curved Surface Development

The difference between developing a single-curved surface (a cylinder) and a double -curved surface (a sphere).

## Multiview Drawing Visualization

$\square$ Reading a drawing means

- being able to look at a two- or three-view multiview drawing and
- form a clear mental image of the threedimensional object.



## Techniques to Visualize Geometry of an Object

- Projection Studies
- Physical Model Construction
- Adjacent Areas
- Similar Shapes
- Surface Labeling
- Missing Lines
- Vertex Labeling
- Analysis by Solids
- Analysis by Surfaces


## Techniques to Visualize Geometry of an Object

## Projection Studies



Examples of the standard representations of various geometric forms.

## Techniques to Visualize Geometry of an Object

## Projection Studies

|  |  |  | H |
| :---: | :---: | :---: | :---: |
| 4 | $\square \leqslant$ | $\square 8$ | $\square$ |
| $\square A$ | $\square \square$ | $\square \in$ | $\square \square$ |
| (©) (0) | $\infty$ |  | $\begin{aligned} & (\mathrm{P})=1 \mathrm{~B}^{\infty} \\ & \square \square \pi^{2} \end{aligned}$ |

Examples of the standard representations of various geometric forms.

## Techniques to Visualize Geometry of an Object

## Physical Model Construction



Orthographic

(C)

(A)

(D)

(B)

(E)

## Creating a Real Model

Using Styrofoam or modeling clay and a knife, model simple 3-D objects to aid the visualization process.

Techniques to Visualize Geometry of an Object

## Physical Model Construction



## A Sulpture Technique

## Techniques to Visualize Geometry of an Object

## Adjacent Areas



Top


Front


Isometric


Right side

Given the top view, make isometric sketches of possible 3-D objects.

## Techniques to Visualize Geometry of an Object

## Adjacent Areas



Top


Front


Isometric


Right side


Possible Solutions.

## Techniques to Visualize Geometry of an Object

## Similar Shapes



## Similar-Shaped Surfaces

Similar-shaped surfaces will retain their basic configuration in all views, unless viewed on edge. Notice that the number of edges of a face remains constant in all the views and that edges parallel in one view remain parallel in other views.

## Techniques to Visualize Geometry of an Object

## Similar Shapes



## Similar-Shaped Surfaces

Similar-shaped surfaces will retain their basic configuration in all views, unless viewed on edge. Notice that the number of edges of a face remains constant in all the views and that edges parallel in one view remain parallel in other views.

## Techniques to Visualize Geometry of an Object

## Surface Labeling



To check the accuracy of multiview drawings, surfaces can be labeled and compared to those in the pictorial view.

## Techniques to Visualize Geometry of an Object

## Missing Lines




Completed multiview

## Missing Line Problems

One way to improve your proficiency is to solve missing-line problems. A combination of holistic visualization skills and systematic analysis is used to identify missing features.

## Techniques to Visualize Geometry of an Object

## Vertex Labeling



Numbering the isometric pictorial and the multiviews to help visualize an object.

## Vertex Labeling



## Techniques to Visualize Geometry of an Object

## Analysis by Solids



A complex object can be visualized by decomposing it into simpler geometric forms.

## Analysis by Solids



Positioned
Primitives

BOOLEAN OPERATIONS


$$
P_{1}-P_{2} \quad P_{2} \fallingdotseq P_{1}
$$

P1 (n) P2


## Analysis by Solids


(c) EAD-notes.EDII




## Analysis by Solids



## Analysis by Solids

## CSG: CONSTRUCTIVE SOLIDS GEOMETRY

Primitives:
Cube, Halfspace, Sphere, Cylinder, Cone, Torus



Boolean Set-operations:
Union,
Intersection,
Difference


CSG-TREE


## Techniques to Visualize Geometry of an Object

## Analysis by Solids



Visualizing a multiview drawing using analysis by solids.

## Techniques to Visualize Geometry of an Object

## Analysis by Solids



## Techniques to Visualize Geometry of an Object

## Analysis by Surfaces



## Techniques to Visualize Geometry of an Object

## Analysis by Surfaces



Visualizing drawing using analysis by surfaces.


Conclusions drawn.

## Visualization Exercise 5.1



## Visualization Exercise 5.2



## Visualization Exercise 5.3



## Surface Labeling



## Visualization Exercise 5.4



## Visualization Exercise 5.5





20,21,22,23.
$19.24^{\circ}$

## Visualization Exercise 5.6



## Visualization Exercise 5.7



## Visualization Exercise 5.8/5.9

Visualize the object by labeling the vertices and surfaces.
Vertex Labeling Surface Labeling


## Visualization Exercise 5.8

## Vertex Labeling



## Visualization Exercise 5.9

## Surface Labeling



## Visualization Exercise 5.10



## (1) Visualization Exercise 5.12



## Visualization Exercise 5.12

## Vertex Labeling




## (2) Visualization Exercise 5.13



## Visualization Exercise 5.13

## Surface Labeling



## (D) Visualization Exercise 5.15

## Analysis by Solids



## Visualization Exercise 5.15

## Analysis by Solids




## Visualization Exercise 5.16

## Surface Labeling



## Problem 5.21 (Figure 161A)

## Surface Labeling

Match the given surface letter from the pictorial drawing with the corresponding surface number from the multiview drawing for each view.


| Surface | Top | Front | Side |
| :---: | :---: | :---: | :---: |
| A |  |  |  |
| B |  |  |  |
| C |  |  |  |
| D |  |  |  |
| E |  |  |  |
| F |  |  |  |
| G |  |  |  |
| H |  |  |  |
| I |  |  |  |
| J |  |  |  |
| K |  |  |  |

(A)

Draw top, front and right side views and number the surfaces.


## Problem 5.1

## Surface Labeling




## Motor Plate

Given the pictorials, sketch or draw using CAD the multiviews and 3-D CAD model.


## Seat

Given the pictorials, sketch or draw using CAD the multiviews and 3-D CAD model.


## Bearing Plate

Given the pictorials, sketch or draw using CAD the multiviews and 3-D CAD model.


## English - Turkish Dictionary

| visualizing | Görüntüleme, <br> gözde canlandırma | solid | Katı (cisim) | cylinder | silindir |
| :--- | :--- | :--- | :--- | :--- | :--- |
| Illustraritve | Açıklayıcı, aydınlatıcı | bulk | Yığın, kütle, <br> hacim | union | birleşim |
| difference | fark | intersection | kesişim | wedge | kama |
| transform | dönüşüm | model | Kalıp, örnek | block | kütük |
| sculpture | Heykel, heykeltraşlık | analysis | İnceleme, analiz | prismatic | Prizma şeklinde |
| basic | Ana, esas | virtual | sanal | corner | köşe |
| surface | yüzey | cone | koni | torus | halka |
| hole | delik | accuracy | doğruluk |  |  |

