MS 101

LECTURE 1

SKETCHING AND VISUALISATION

TEXTBOOKS REFERRED TO

MAIN BOOKS

- **Text Book 1:** Dennis K. Lieu and Sheryl Sorby, Visualization, Modeling, and Graphics for Engineering Design
- **Text Book 2:** N. D. Bhatt and V. M. Panchal, Engineering Drawing, Charotar Publishers

REFERENCE BOOKS :

- Warren J. Luzadder and Jon M. Duff, Fundamentals of Engineering Drawing, Prentice-Hall of India
- Thomas E. French, Charles J. Vierck and Robert Foster, Engineering Drawing and Graphic Technology, McGraw Hill
- Dhananjay A. Jolhe, Engineering Drawing, Tata McGraw Hill Publishing Co. Ltd.
- M. B. Shah and B. C. Rana, Engineering Drawing, Dorling Kindersley (India) Pvt. Ltd., Pearson Education

CREDITS FOR SLIDES

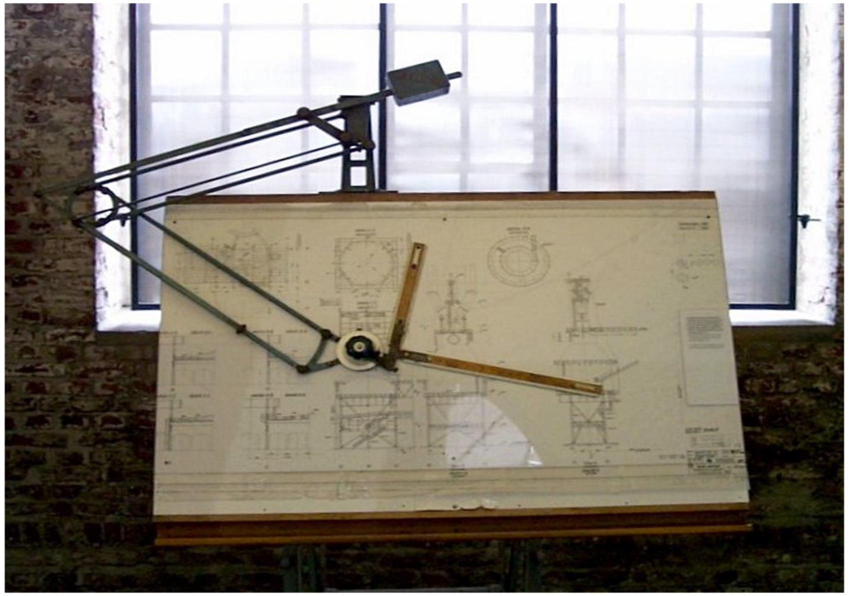
- Many slides are taken from Prof. Anirban Guha, ME, IITB, Prof. Amit Singh, ME, IITB

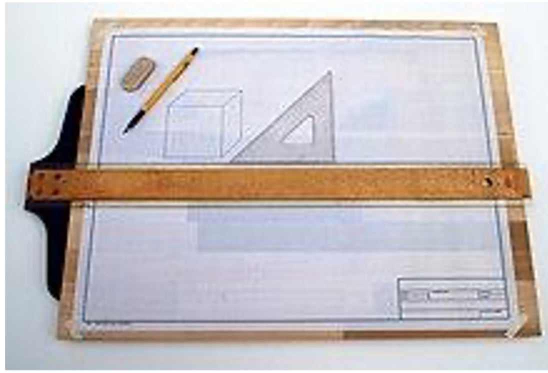
Prof. Krishna Jonnalagadda, ME, IITB

Engineering Graphics Technology

INSTRUMENT DRAWING:

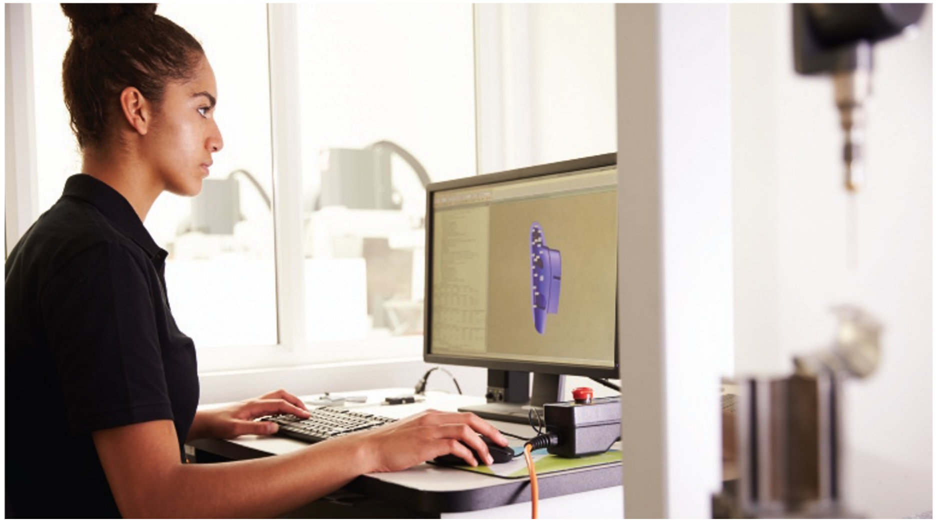
Drafting board, T-square, Set-square, Scale, Compass, Protractor, French Curves, Drawing papers, Pencils, Eraser, Drawing pins, Sand paper, Duster, Drafting machine.

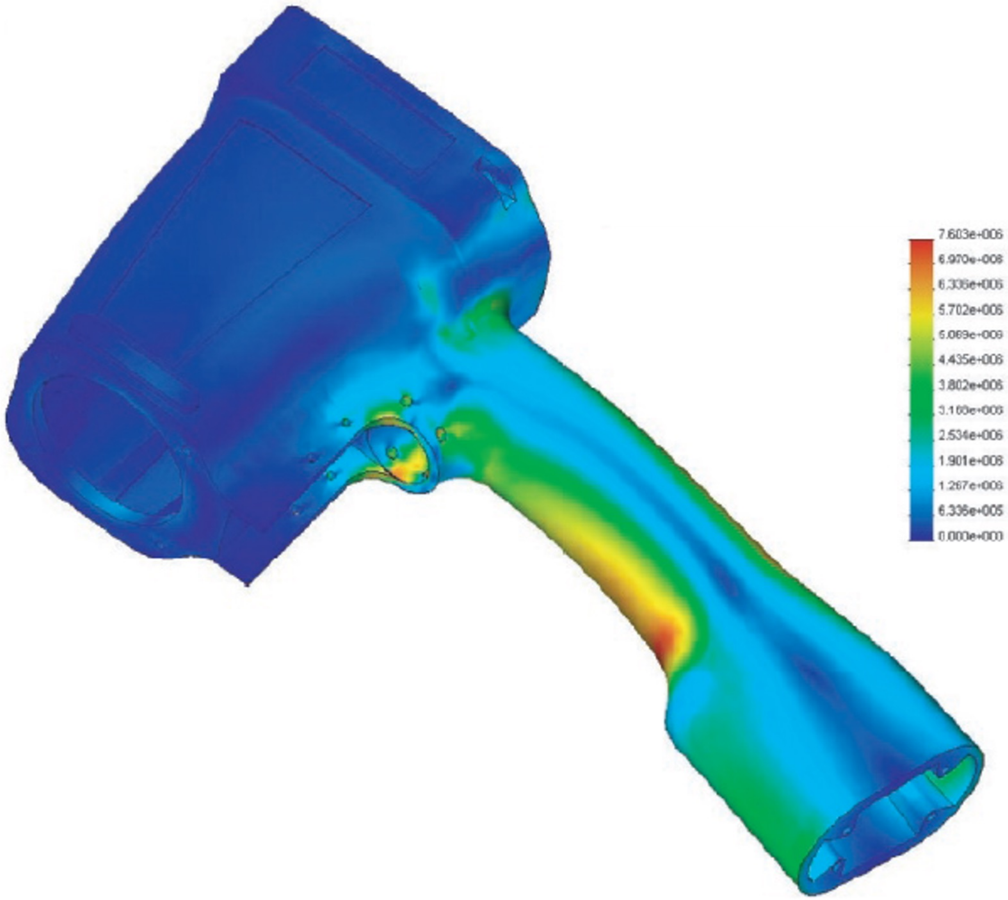




Engineering Graphics Technology

COMPUTER AIDED WITH SOFTWARE:

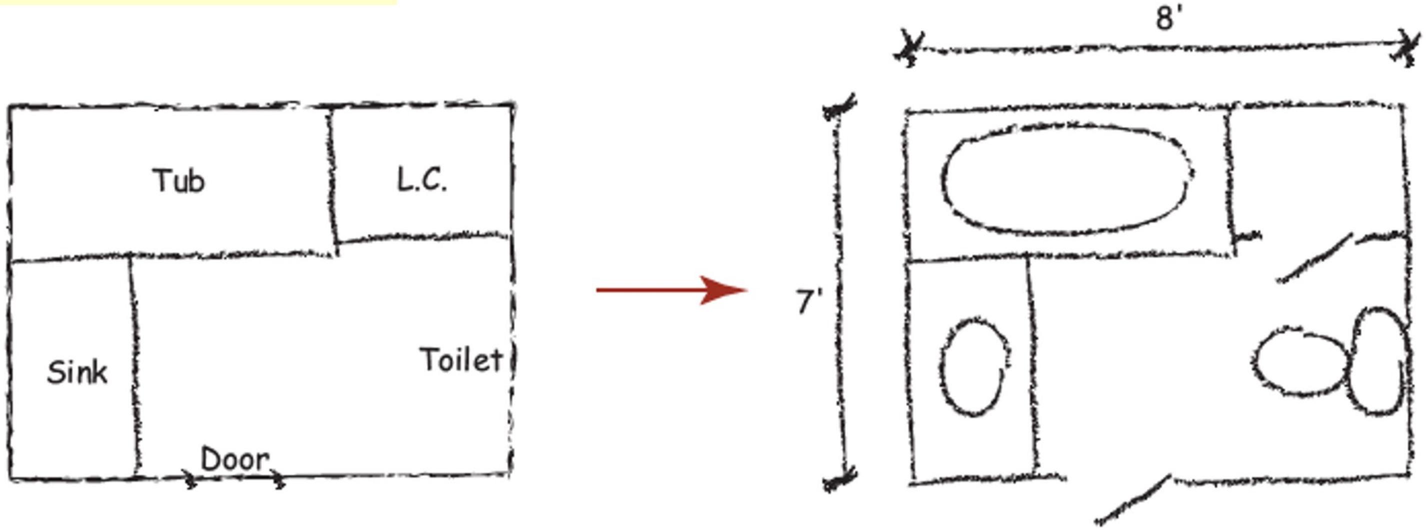




THIS COURSE WILL ADOPT THIS METHOD: AUTODESK FUSION 360

SKETCHING - A drawing without the use of drawing instrument

A rough idea, e.g. sketch of a bathroom

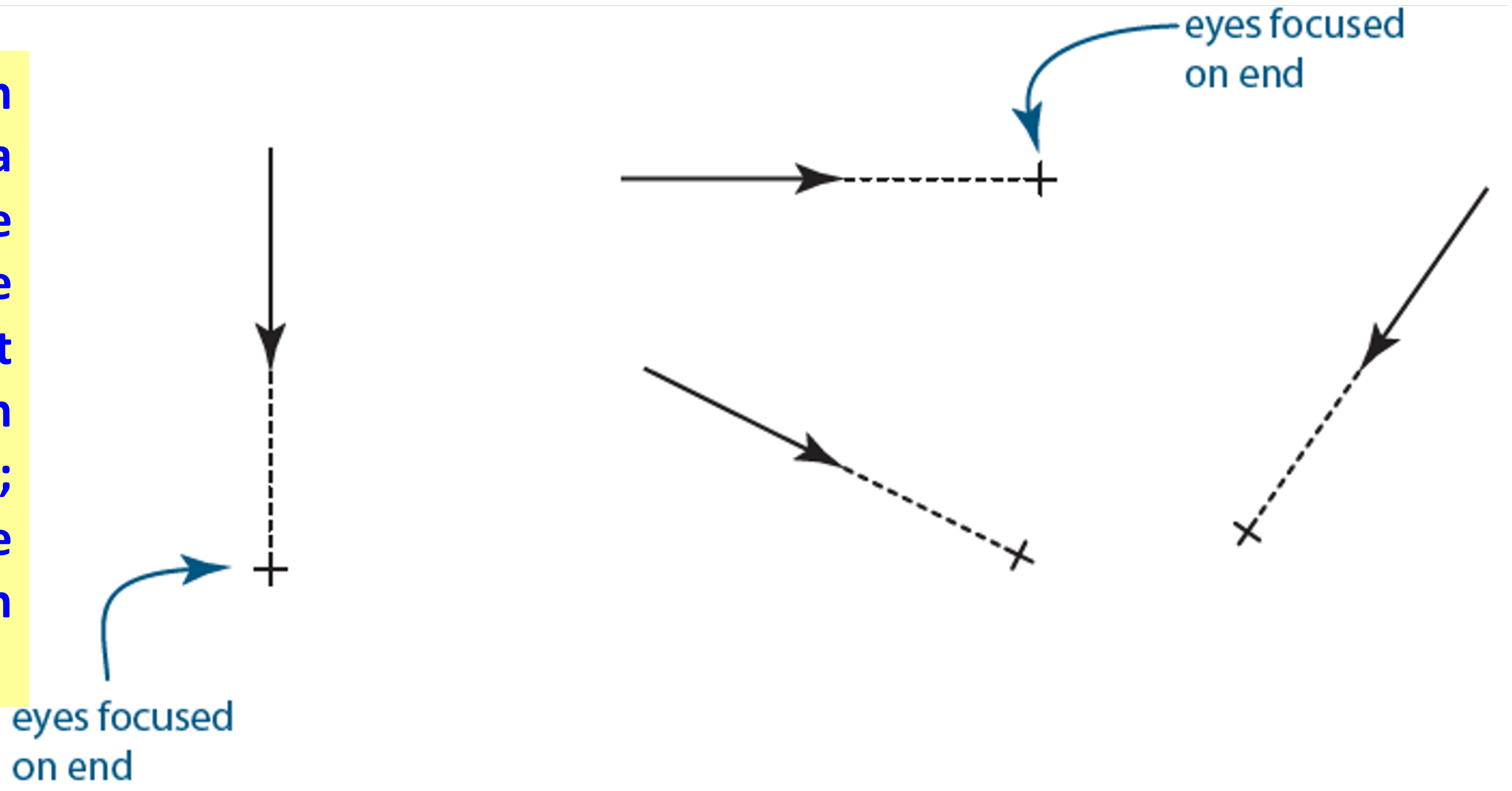


- When engineers sit down to brainstorm solutions to problems, before long, one of them usually takes out a sheet of paper and sketches an idea on it.
- The others in the discussion may add to the original sketch, or they may create sketches of their own.
- The paper-and-pencil sketches become media for the effective exchange of ideas

SKETCHING LINES

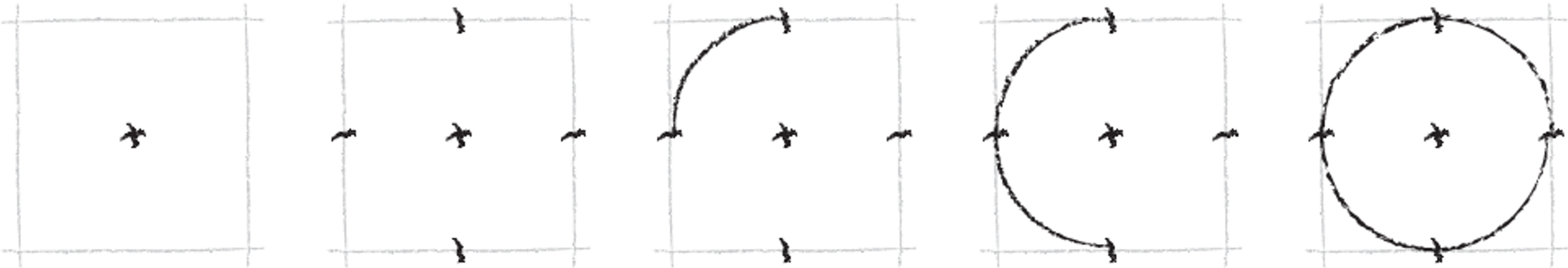
When sketching lines, the key is to make them as straight as possible.
Sketch your vertical lines from top to bottom and your horizontal lines from left to right.

If you are sketching an angled line, choose a direction that matches the general inclination of the line—for angled lines that are mostly vertical, sketch them from top to bottom; for angled lines that are mostly horizontal, sketch them from left to right.



For right-handed person

SKETCHING CURVED ENTITIES



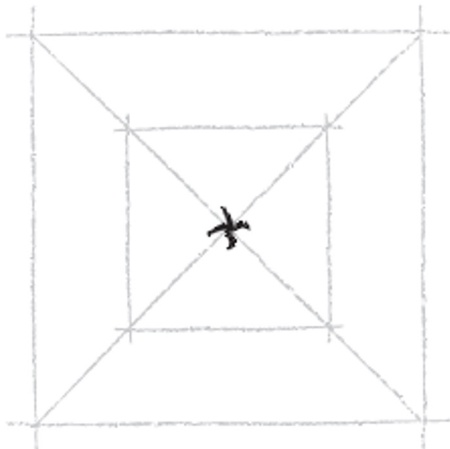
Bounding box with circle center

Radial tick marks added to boundary box

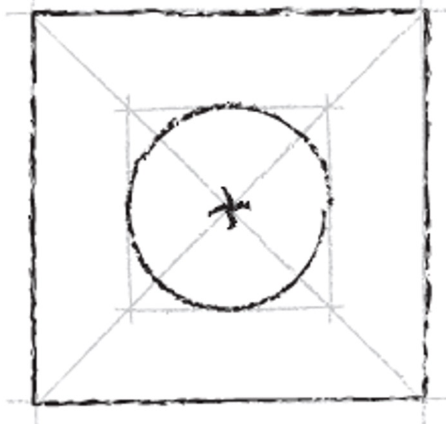
First arc drawn

Second arc drawn

Circle complete

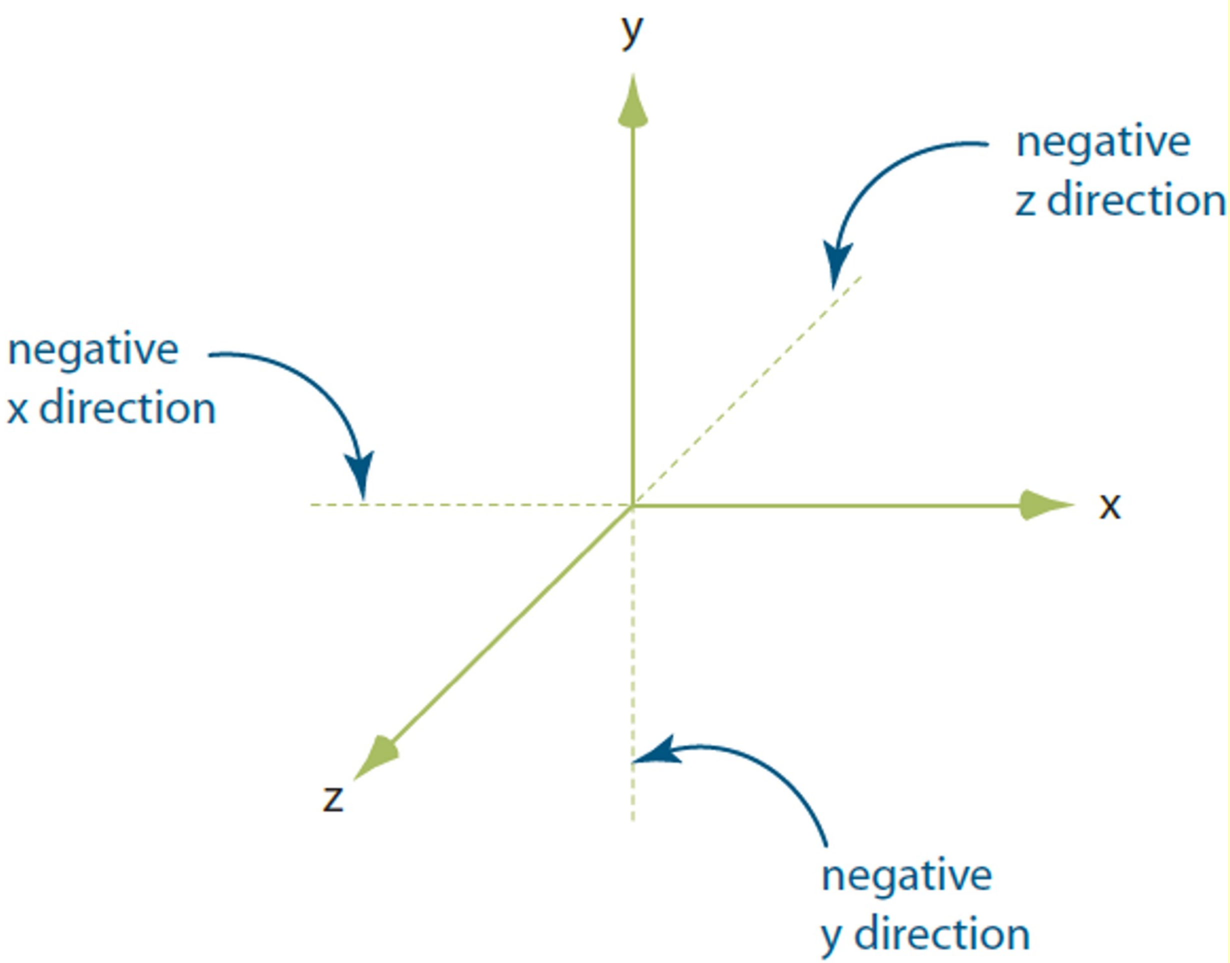


Concentric bounding boxes



Circle centered in square

COORDINATE SYSTEM - Need to portray 3-D objects on a flat 2-D sheet of paper



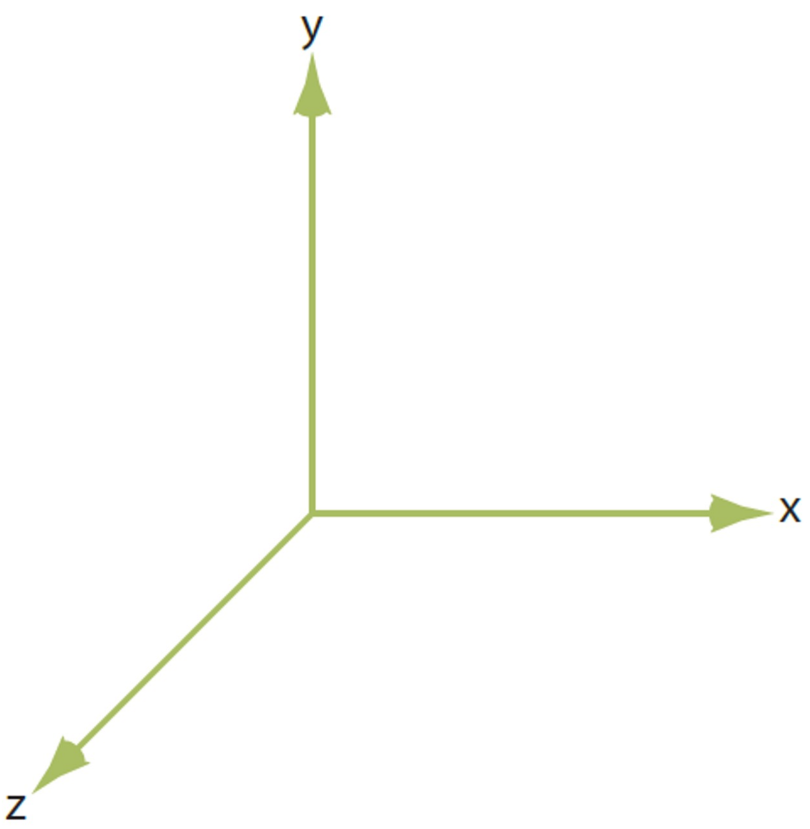
3-D COORDINATE SYSTEM

Space can be represented by three mutually perpendicular coordinate axes, typically the x-, y-, and z-axes

To visualize these three axes, look at the bottom corner of the room. Notice the lines that are formed by the intersection of each of the two walls with the floor and the line that is formed where the two walls intersect. we can think of these lines of intersection as the x-, y-, and z-coordinate axes.

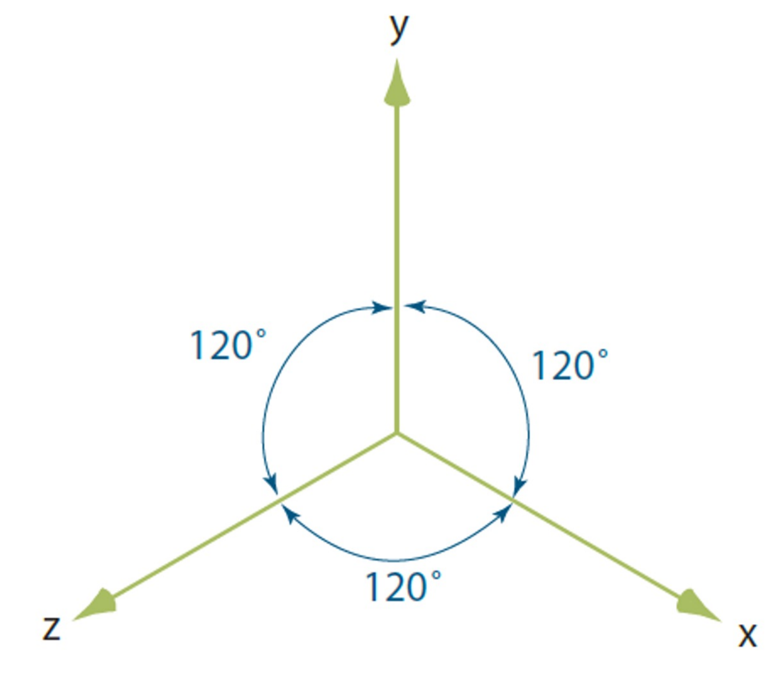
We can define all locations in the room with respect to this corner, just as all points in 3-D space can be defined from an origin where the three axes intersect.

OBLIQUE AXIS REPRESENTATION



Two axes perpendicular, third at an angle of 45 degrees to both axes

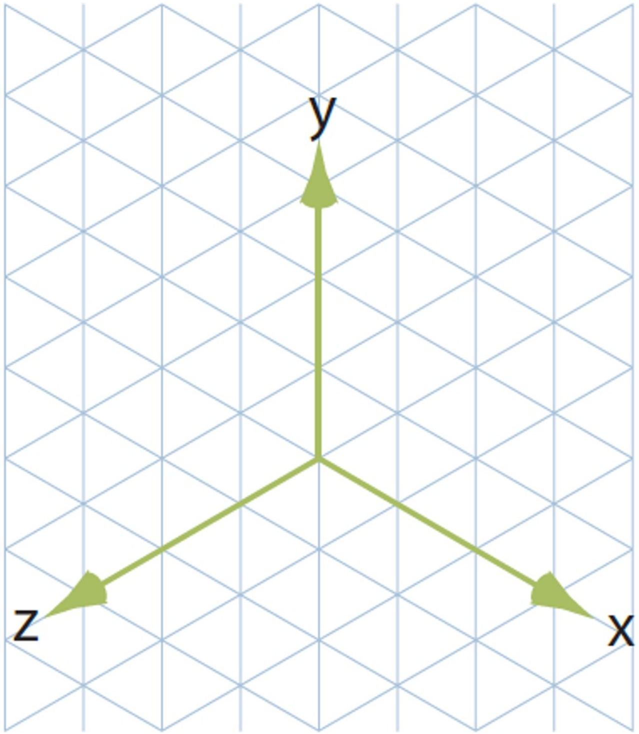
ISOMETRIC REPRESENTATION



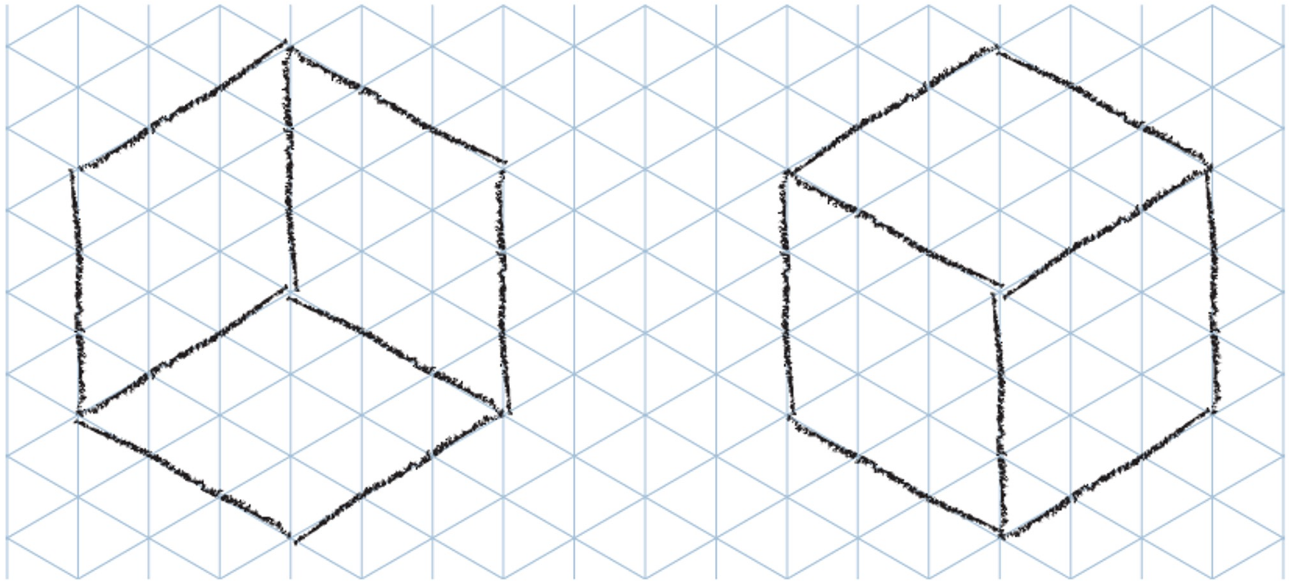
Axes projection as if looking down diagonal of the cube. 120 degrees all axes

ISOMETRIC SKETCHES

ISOMETRIC GRID : Lines are drawn are oriented in such a manner that standard 120 degree coordinate axes are obtained.

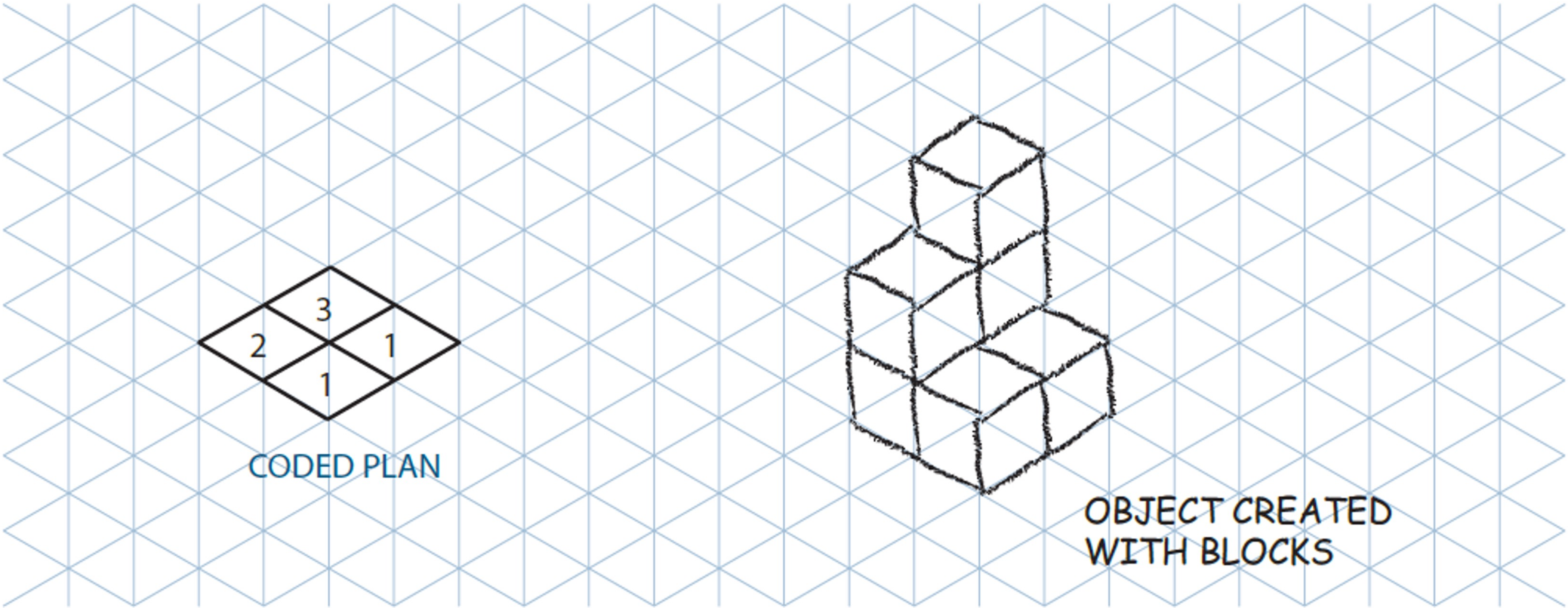


USING ISOMETRIC GRID PAPER TO SKETCH A BLOCK

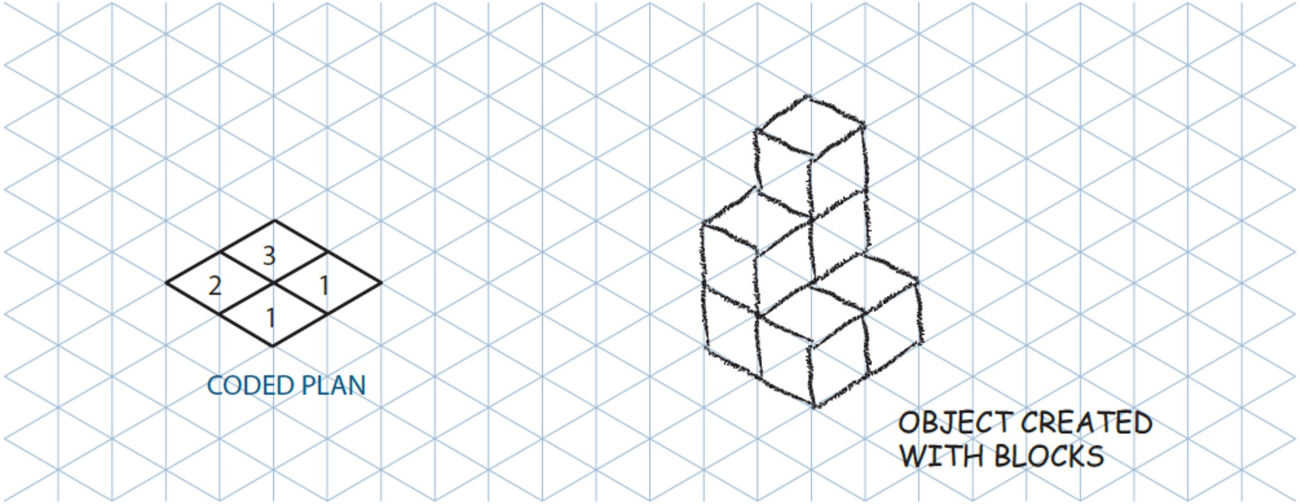


ISOMETRIC SKETCHES

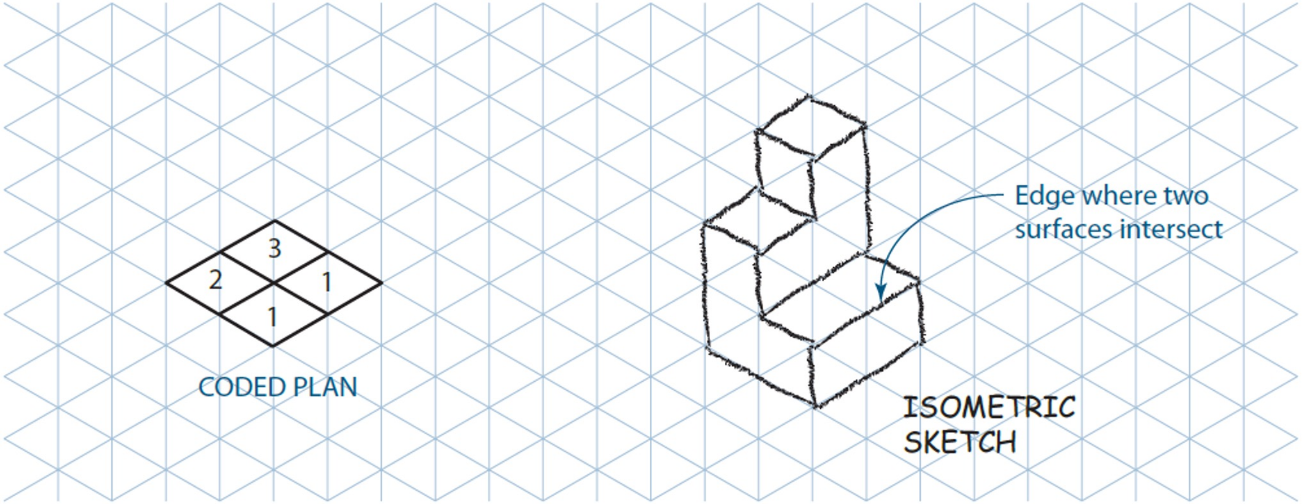
Coded plans: Lines appear only when two surfaces intersect



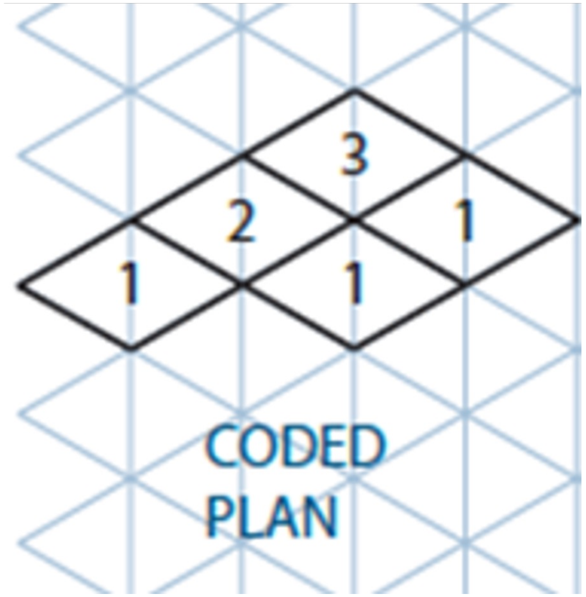
ISOMETRIC SKETCHES

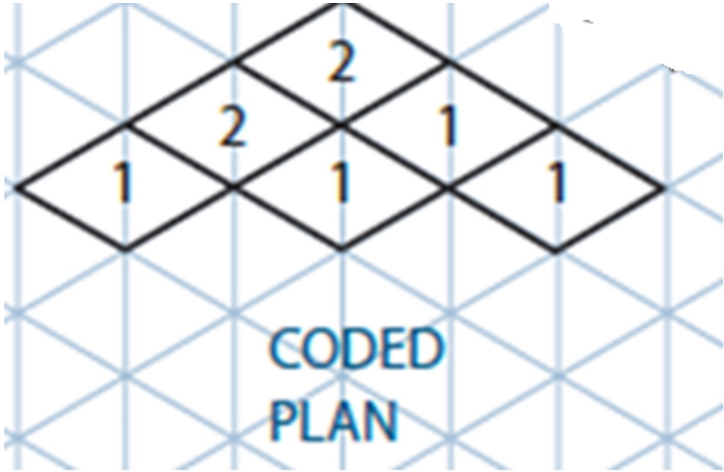


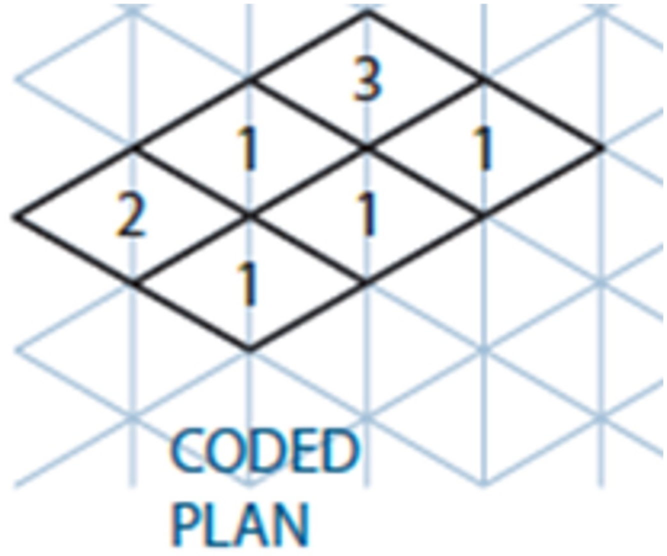
A coded plan and the resulting object

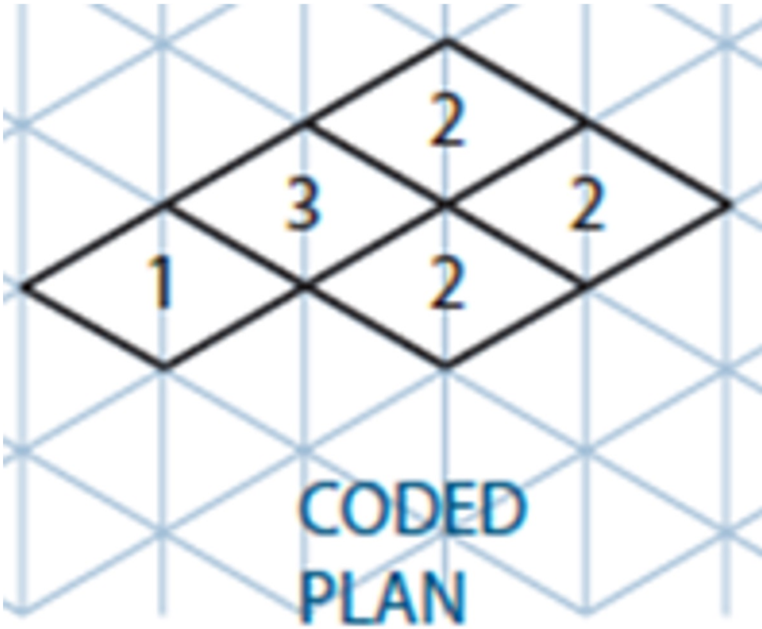


A properly drawn isometric sketch of the object from the coded plan

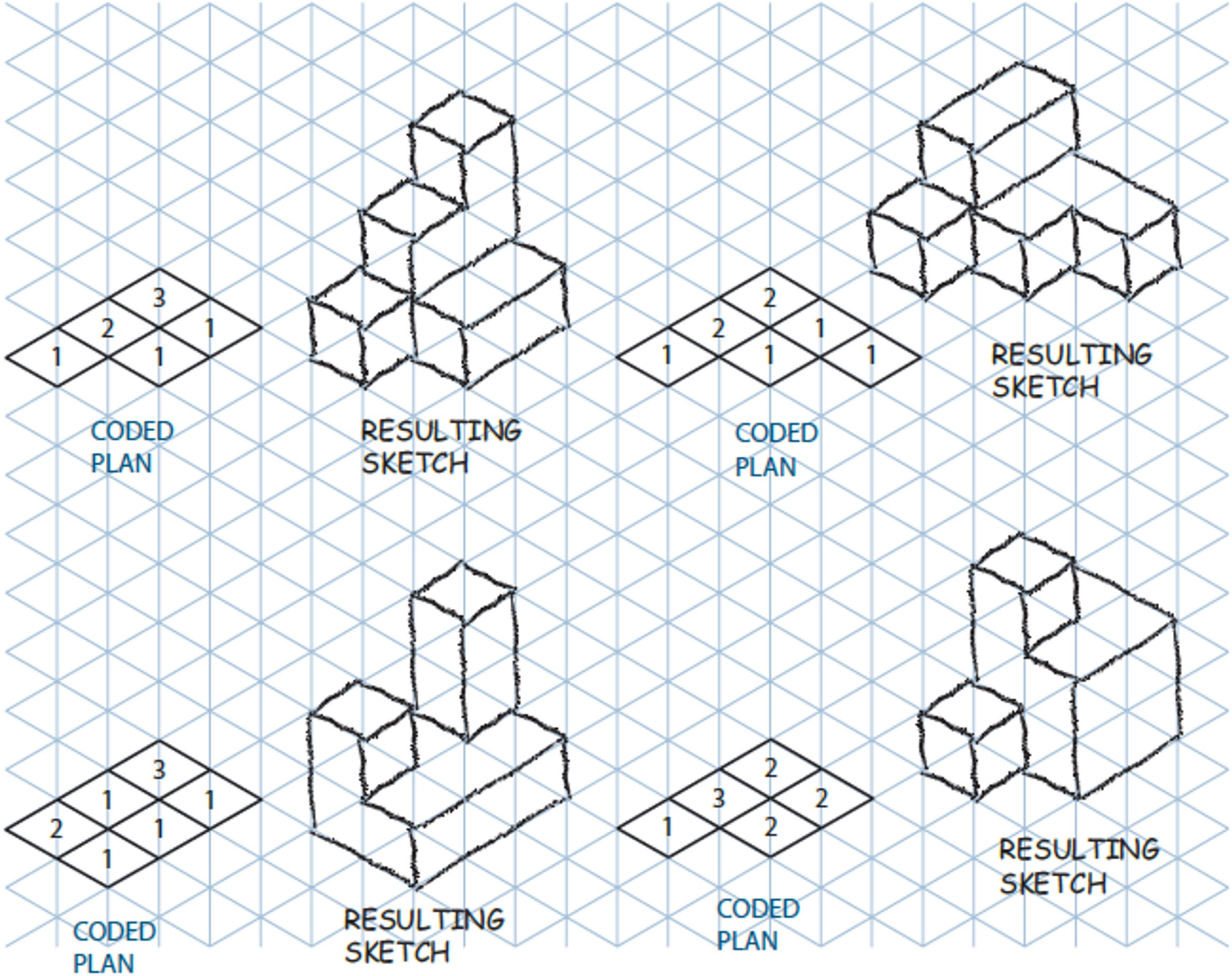

3
2
1
1
1
CODED
PLAN


2
2
1
1
1
1
CODED
PLAN

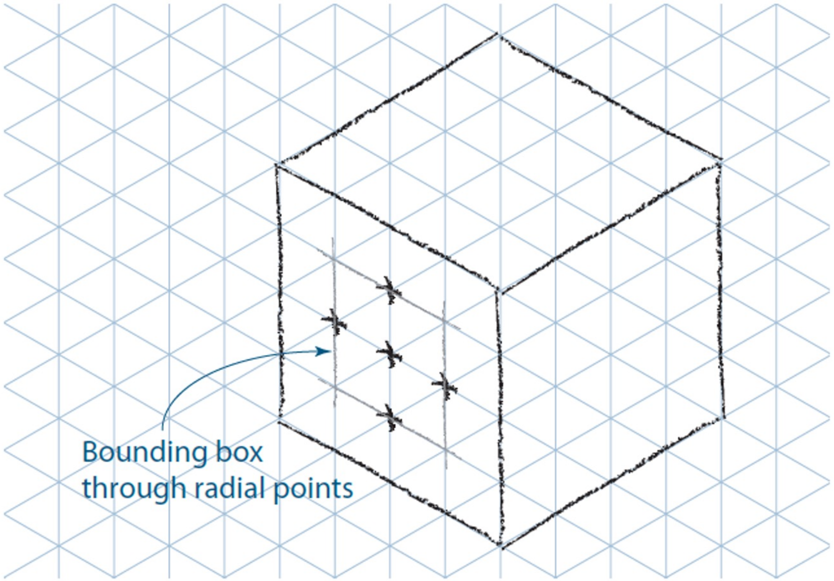

3
1
1
2
1
1
CODED
PLAN

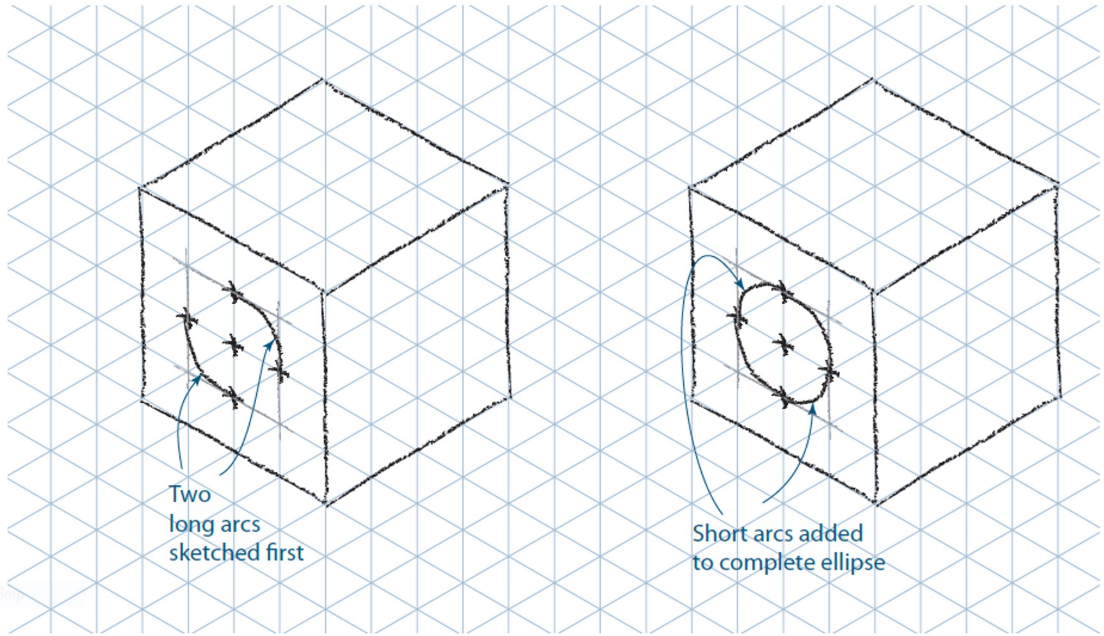

2
3
2
1
2
CODED
PLAN

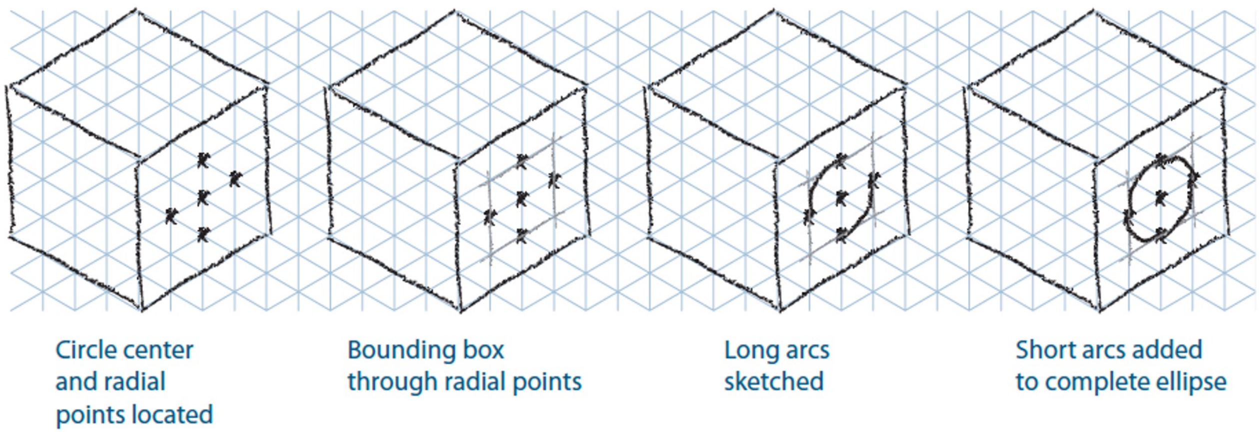
ISOMETRIC SKETCHES



Circles and holes in isometric sketches

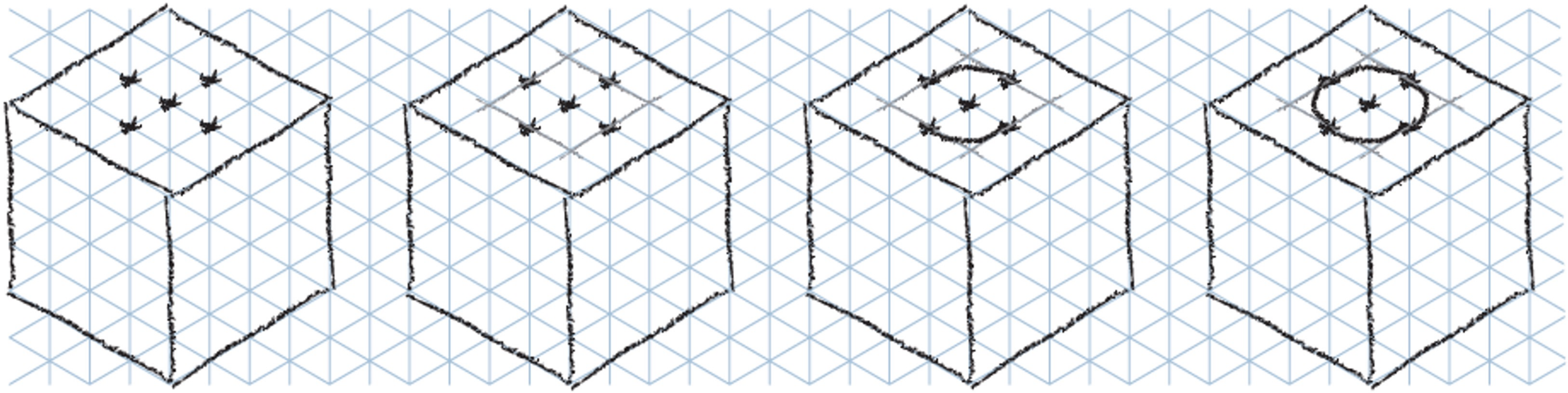






Sketching an ellipse on the side face of a cube

Sketching an ellipse on the top surface of a cube



Circle center and radial points located

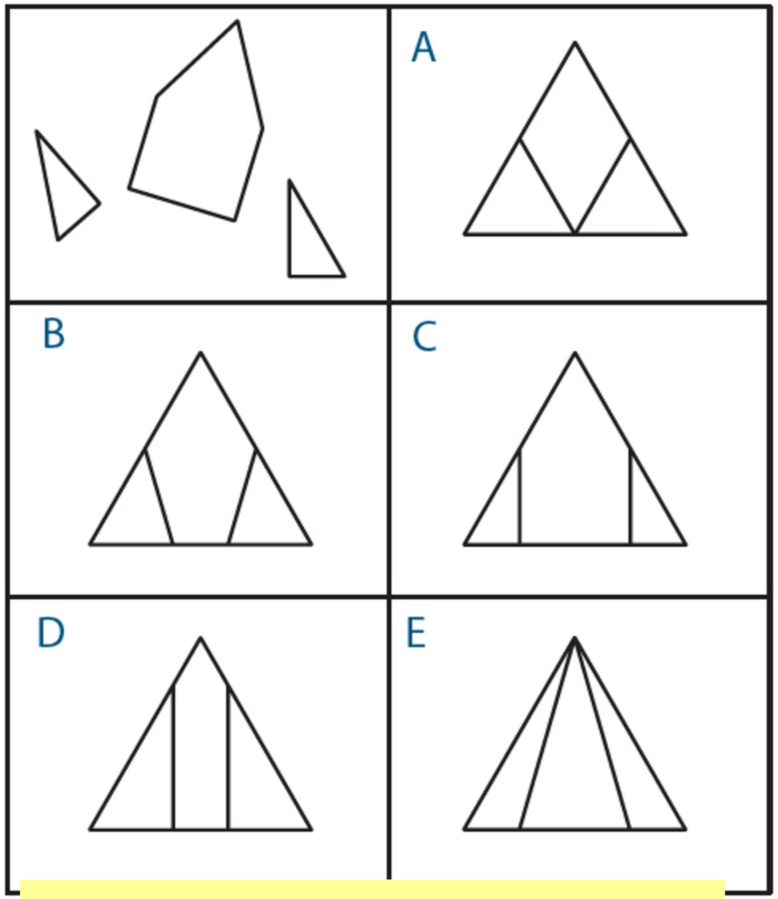
Bounding box through radial points

Long arcs sketched

Short arcs added to complete ellipse

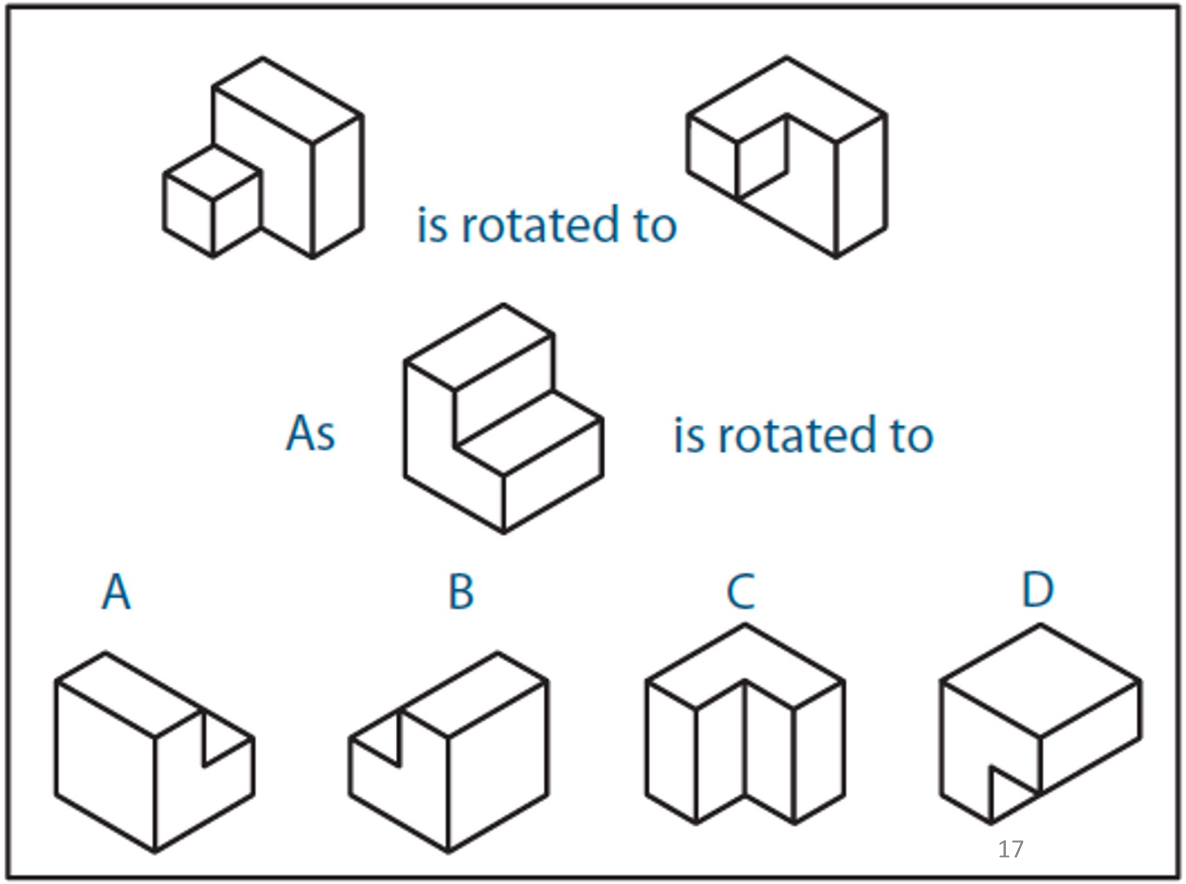
VISUALISATION - Assessing spatial skills

SPATIAL ABILITY: the ability to mentally manipulate, rotate, twist, or invert pictorially presented visual stimuli



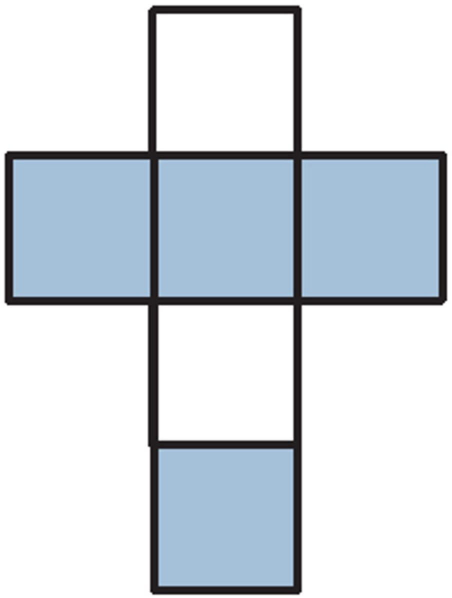
PAPER FORM BOARD TEST - C

MENTAL ROTATION TEST

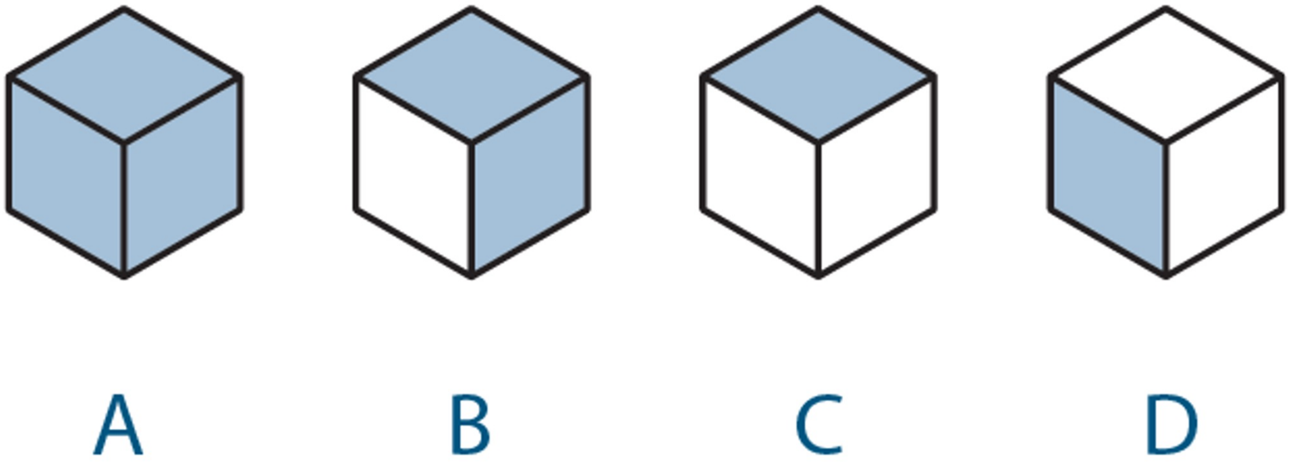


Differential Aptitude Test: Space Relations – DEVELOPMENT OF SURFACES

This test is designed to measure your ability to move from the 2-D to the 3-D world.
The objective is to mentally fold the 2-D pattern along the solid lines, which designate the fold lines, so the object will result in the 3-D shape



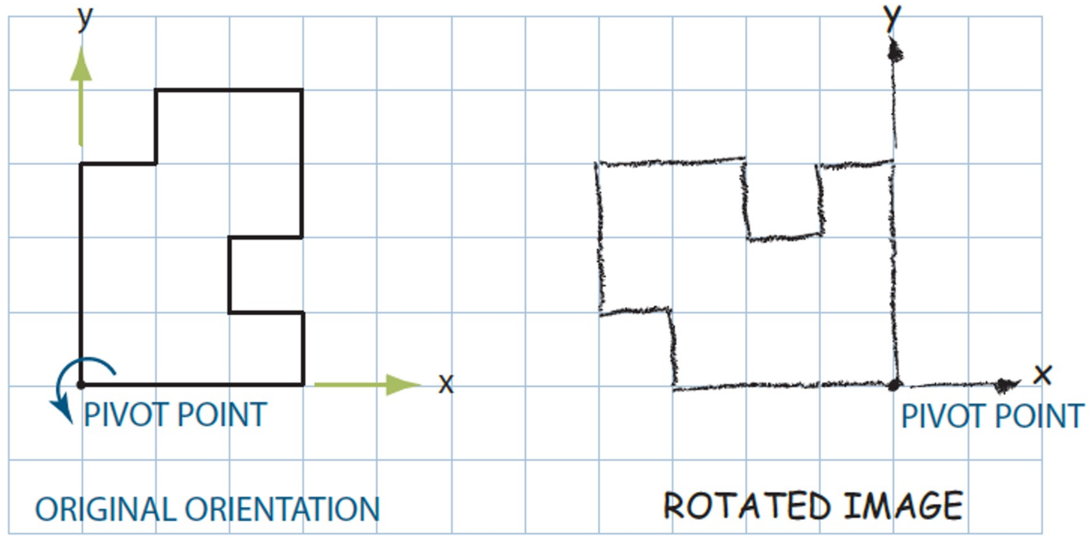
B



OBJECT ROTATIONS ABOUT A SINGLE AXIS

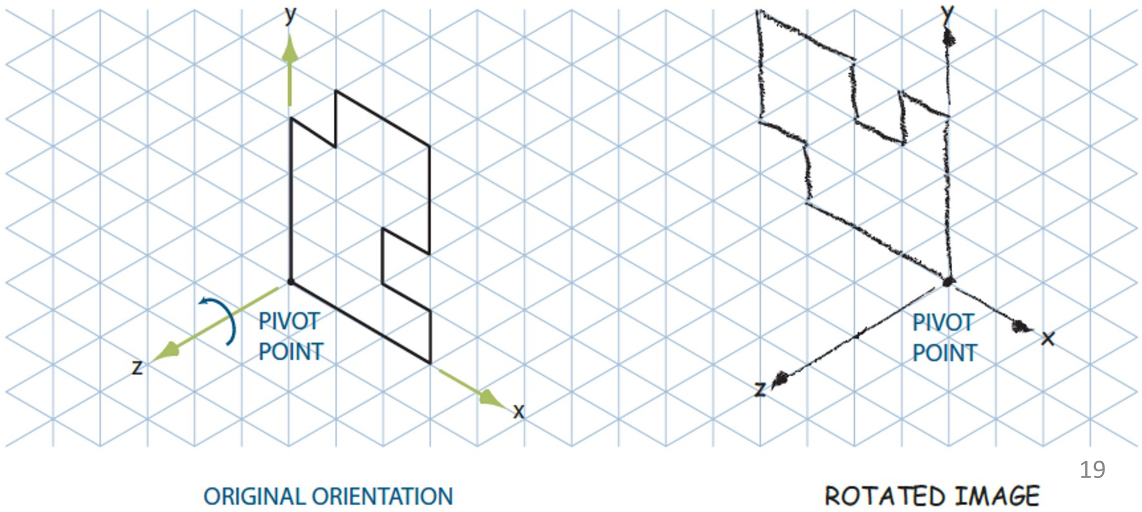
A shape rotated about a pivot point in 2-D space

A 2-D object rotated 90 degrees counterclockwise (CCW) about the pivot point



A 2-D shape rotated in 3-D space

A 2-D object rotated 90 degrees counterclockwise (CCW) about the z-axis



OBJECT ROTATIONS ABOUT A SINGLE AXIS

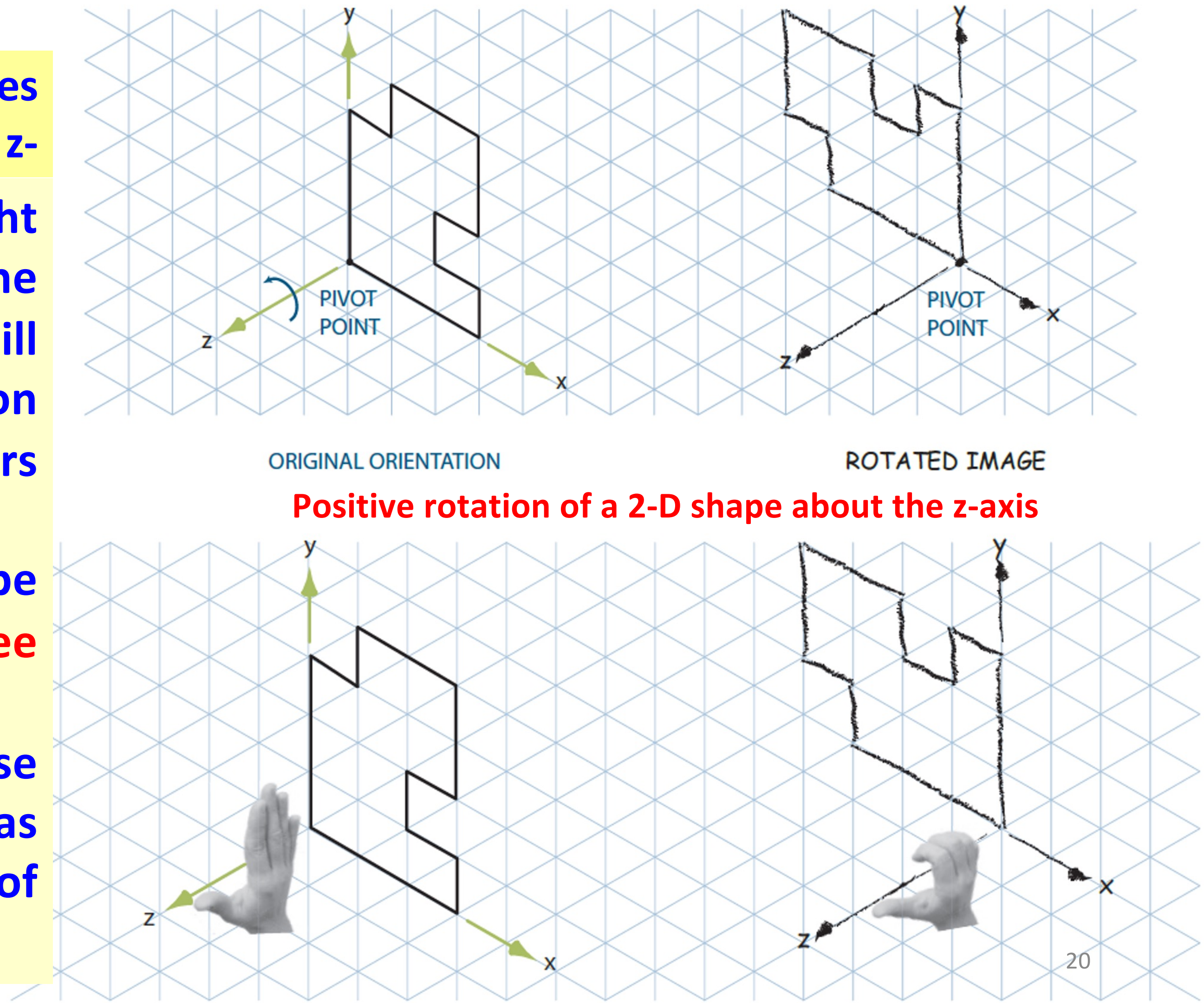
A 2-D shape rotated in 3-D space

A 2-D object rotated 90 degrees counterclockwise (CCW) about the z-

If you point the thumb of your right hand in the positive direction of the z-axis and curl your fingers, you will see that the 90-degree CCW rotation mimics the direction that your fingers curl as in Figure.

This CCW rotation of the 2-D shape represents a *positive* 90-degree rotation about the z-axis.

The CCW rotation is positive because the thumb of your right hand was pointing in the positive direction of the z-axis as the shape was rotated.

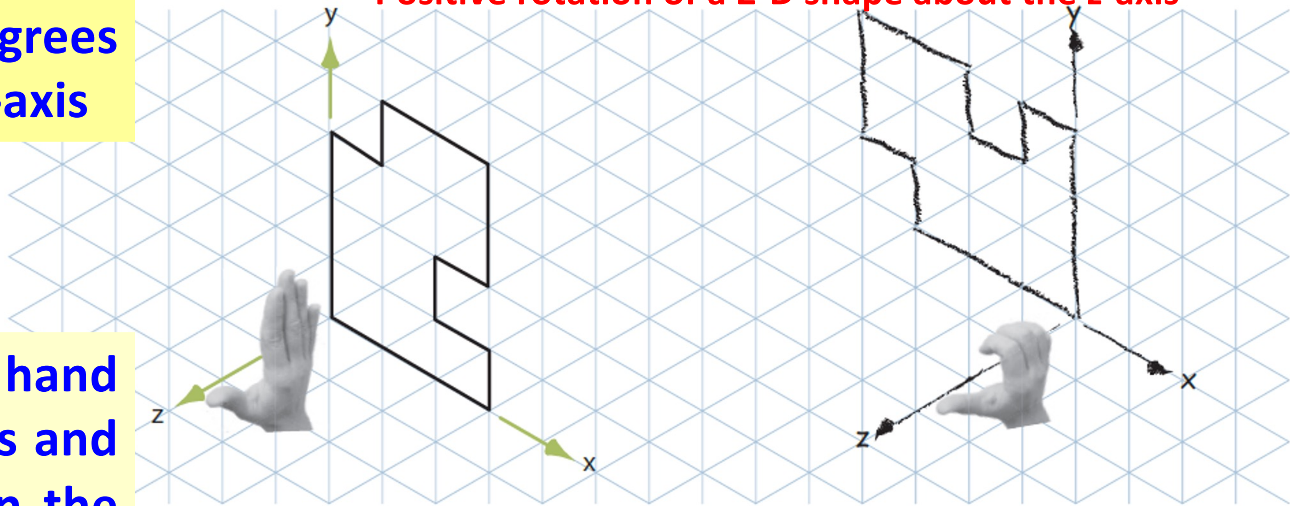


Positive rotation of a 2-D shape about the z-axis

OBJECT ROTATIONS ABOUT A SINGLE AXIS

A 2-D object rotated 90 degrees counterclockwise (CCW) about the z-axis

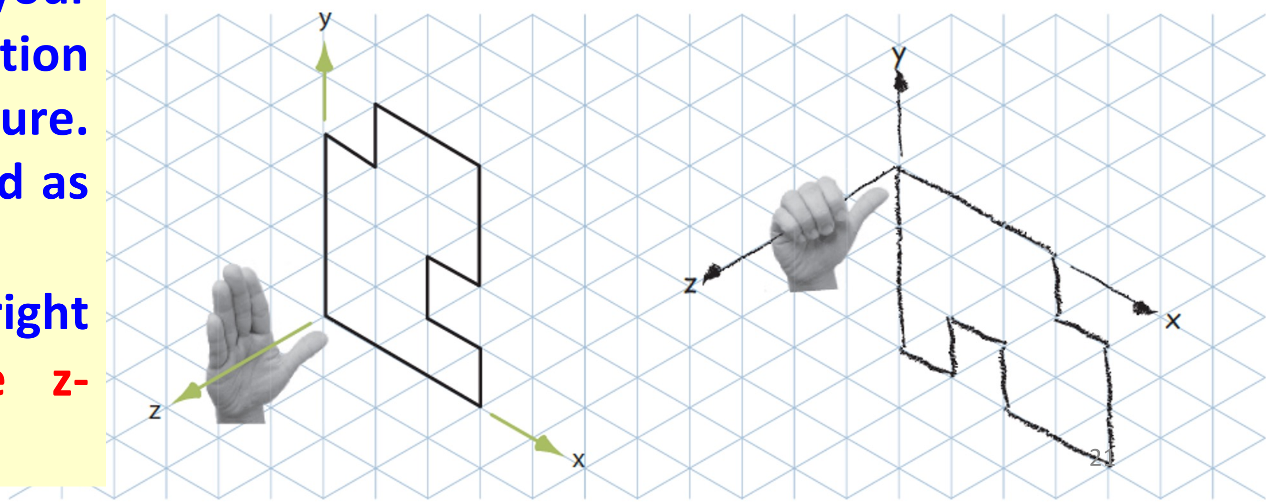
Positive rotation of a 2-D shape about the z-axis

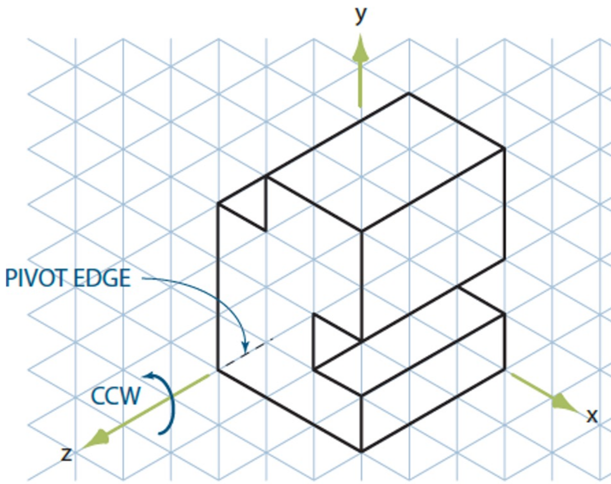


If you point the thumb of your right hand in the negative direction of the z-axis and the shape is rotated in the direction the fingers of your right hand curl, your fingers indicate a clockwise (CW) rotation of the shape about the z-axis, as in Figure. A CW rotation about an axis is defined as a negative rotation.

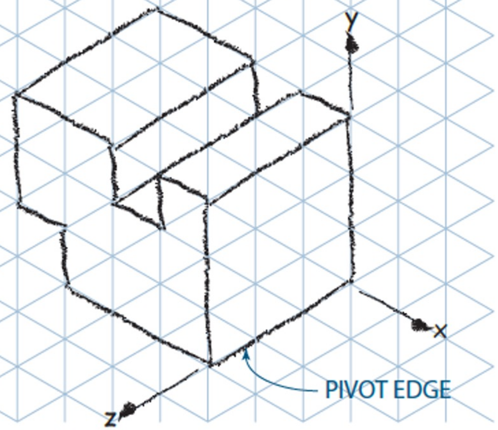
Remember that the thumb of your right hand is pointing in the negative z-direction.

Negative rotation of a 2-D shape about the z-axis



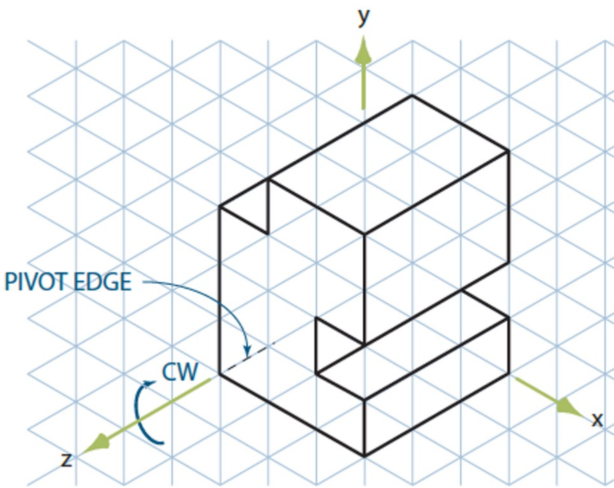


ORIGINAL ORIENTATION

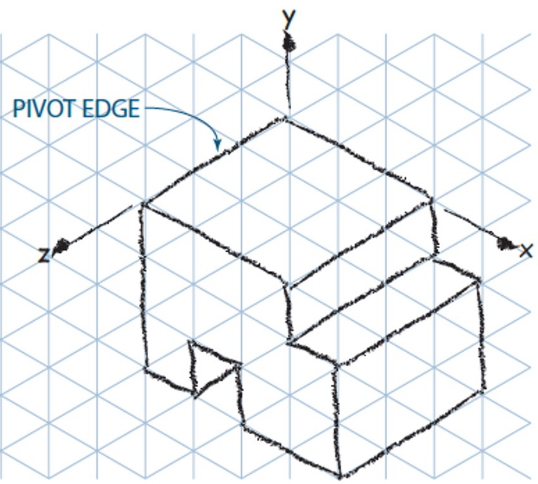


ROTATED IMAGE

A 3-D object rotated 90 degrees counterclockwise about the z-axis



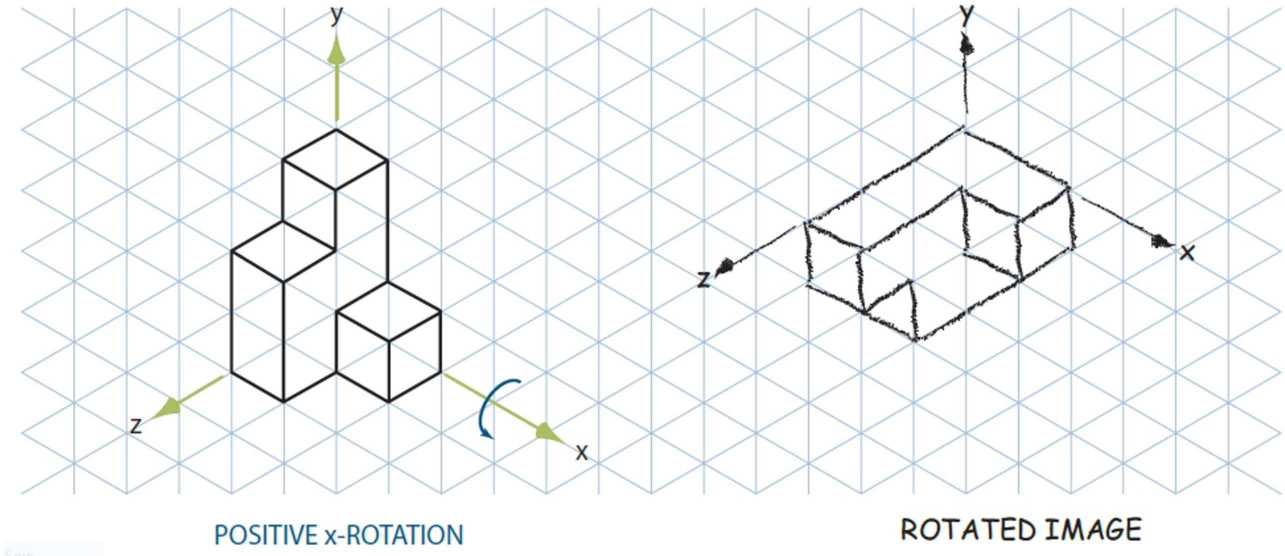
ORIGINAL ORIENTATION



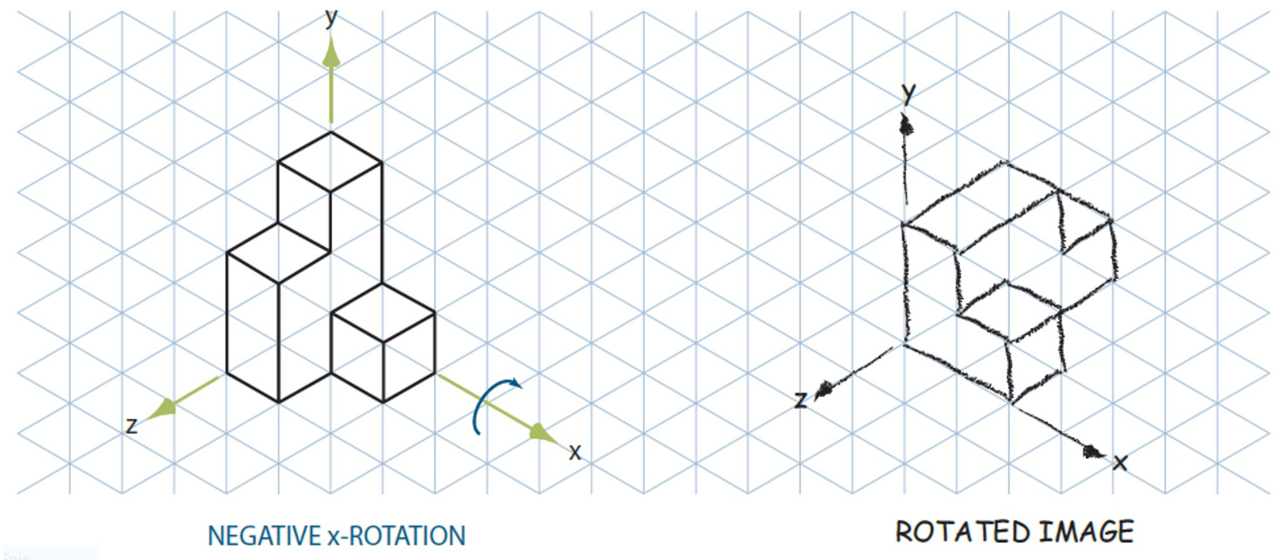
ROTATED IMAGE

A 3-D object rotated 90 degrees clockwise about the z-axis.

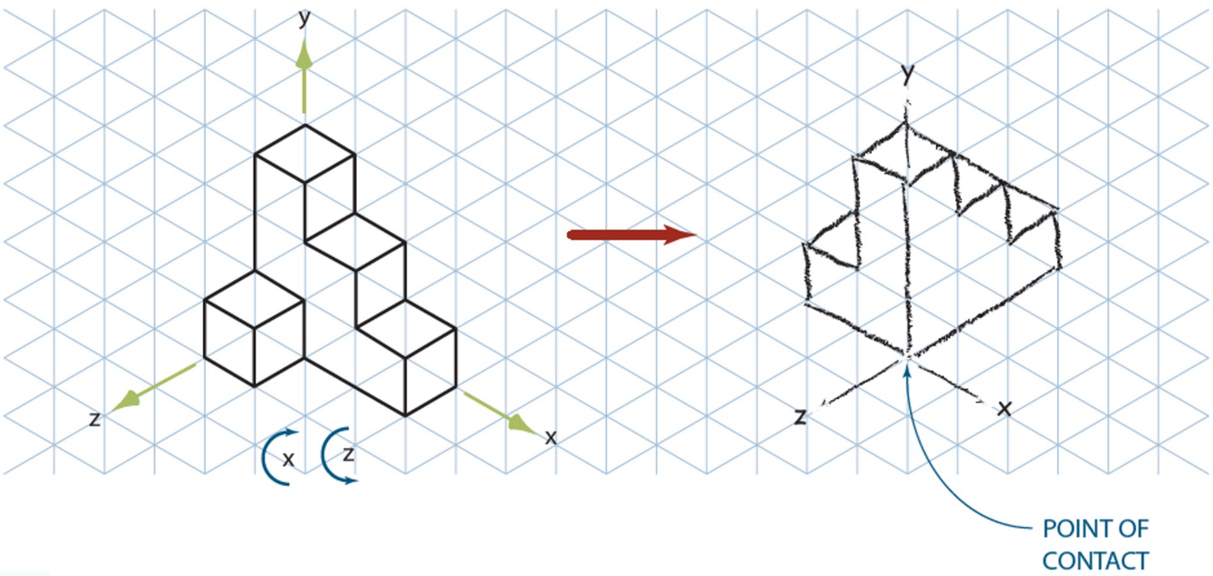
Positive rotation about the x-axis



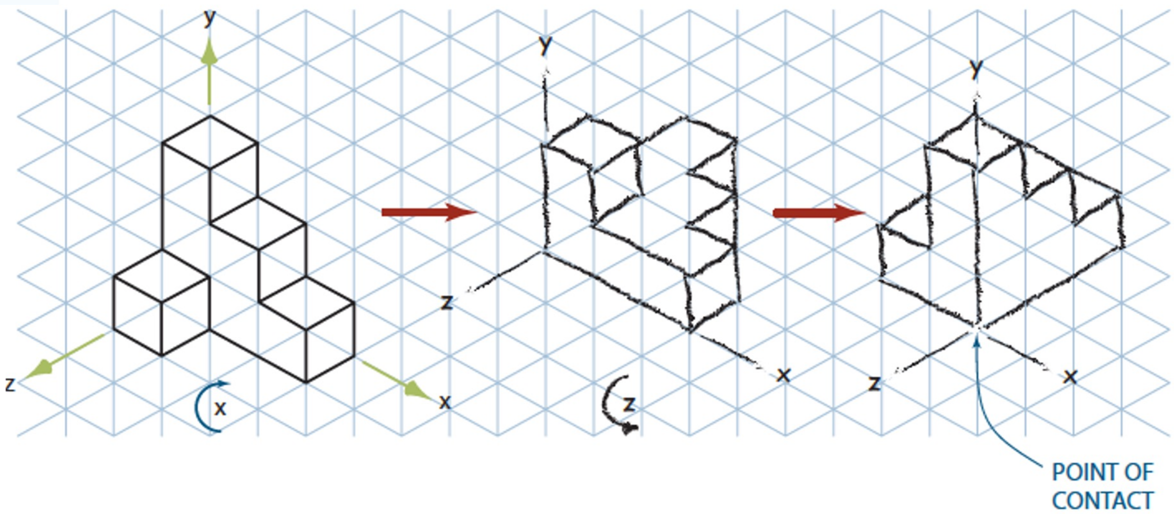
Negative rotation about the x-axis



ROTATION ABOUT TWO OR MORE AXES

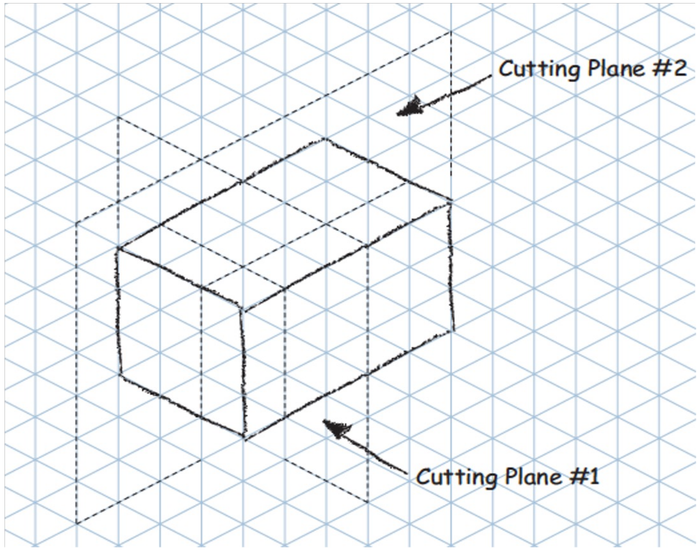


An object rotated about two axes



An object rotated in two steps

CROSS SECTIONS OF SOLIDS

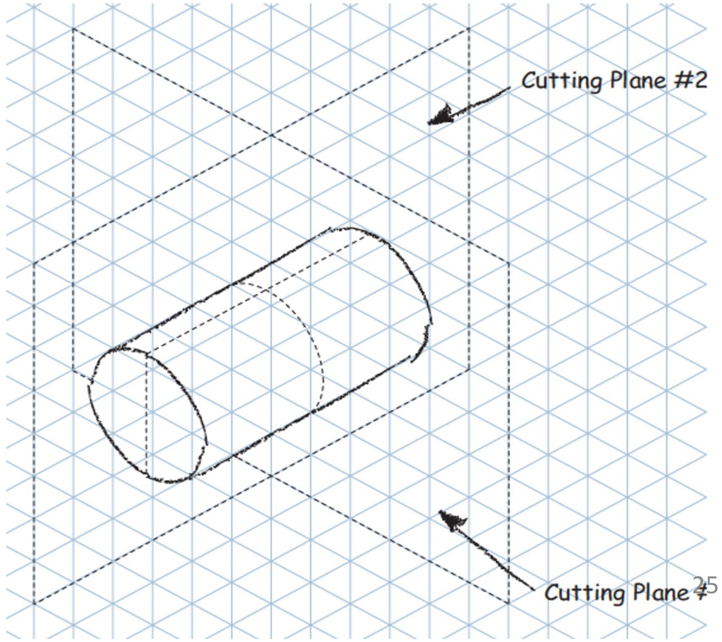


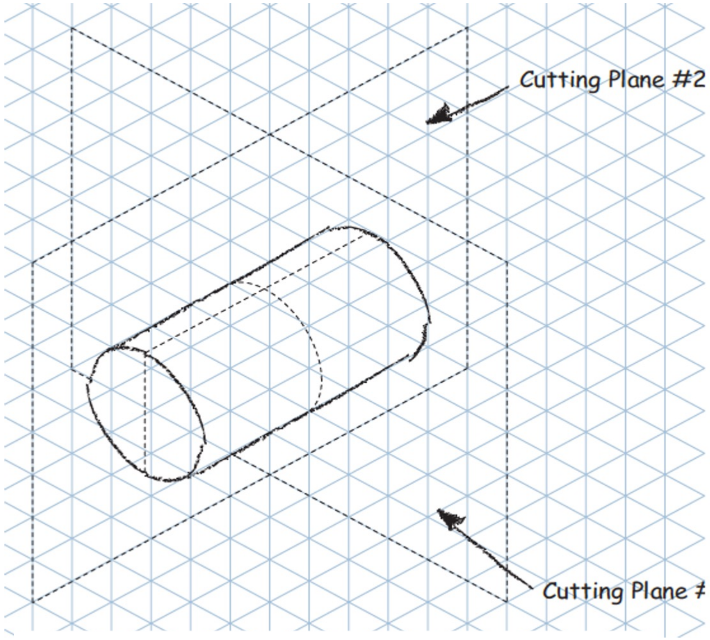
Cross Section #1

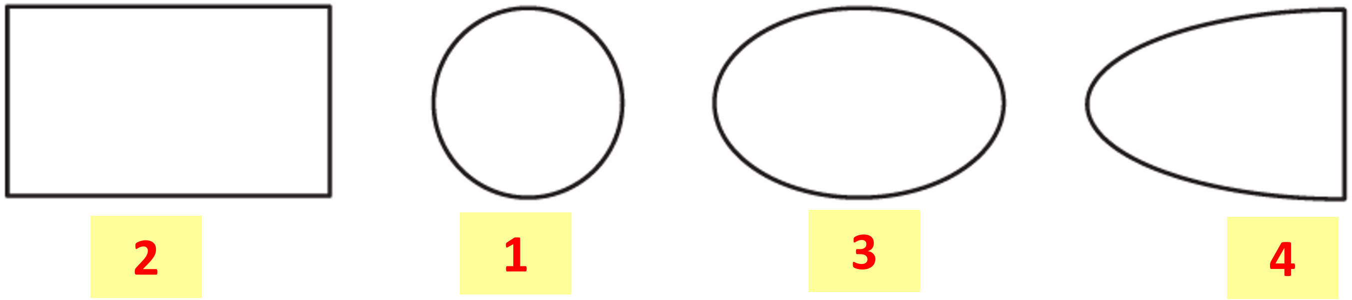
Cross Section #2

Cross Section #1

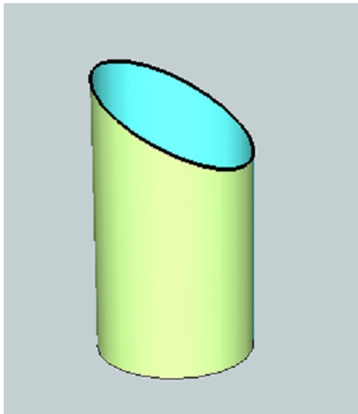
Cross Section #2



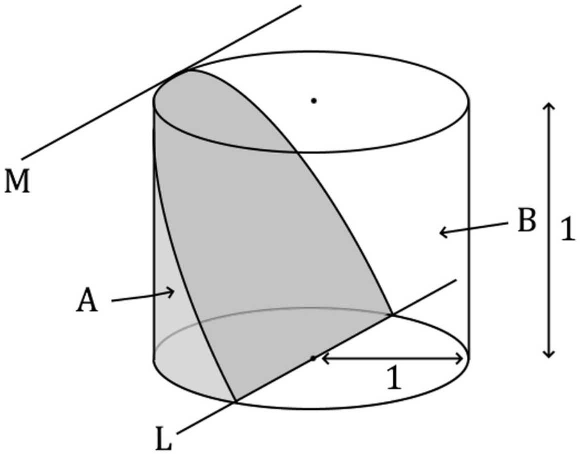




SEVERAL CROSS SECTIONS OF A CYLINDER

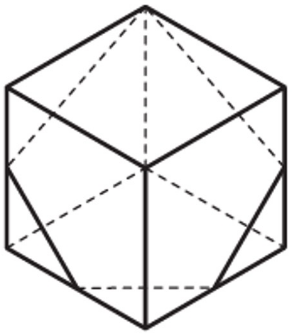


Third cross section - obtained by orienting the cutting plane at an angle with respect to the axis of the cylinder

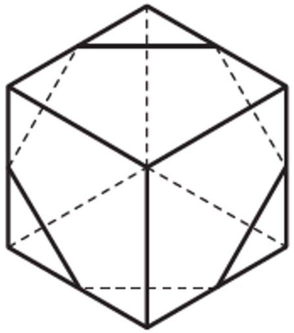


Fourth cross section - obtained by angling the cutting plane with respect to the cylinder axis, but the angle was such that a portion of the cutting plane went through the flat circular end surface of the cylinder

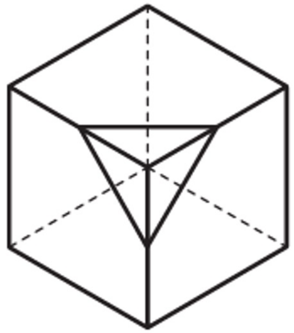
SEVERAL CROSS SECTIONS OBTAINED BY SLICING A CUBE WITH CUTTING PLANES AT DIFFERENT ORIENTATIONS



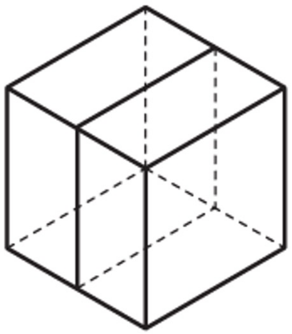
Pentagon



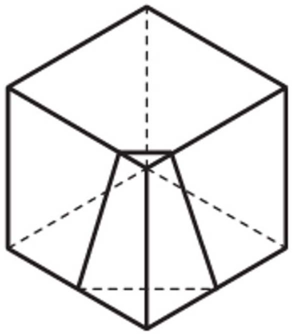
Hexagon



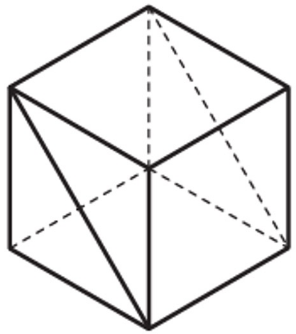
Triangle



Square



Trapezoid



Rectangle

COMBINING SOLIDS

The ability to visualize combining solids will be helpful as you learn how to use solid modeling software.

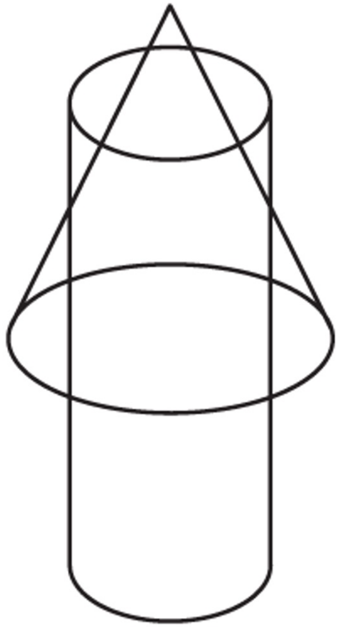
In early versions of 3-D CAD software, commands used to combine solids were sometimes known as Boolean operations.

Two overlapping objects can be combined to form a third object with characteristics of each original object apparent in the final result.

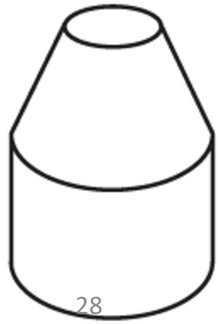
To perform any Cut, Join, or Intersect operation to combine objects, the objects must be overlapping initially.

OVERLAPPING – objects share a common volume in 3-D space—called the VOLUME OF INTERFERENCE

Volume of interference takes shape and size characteristics from each of the two initial objects.

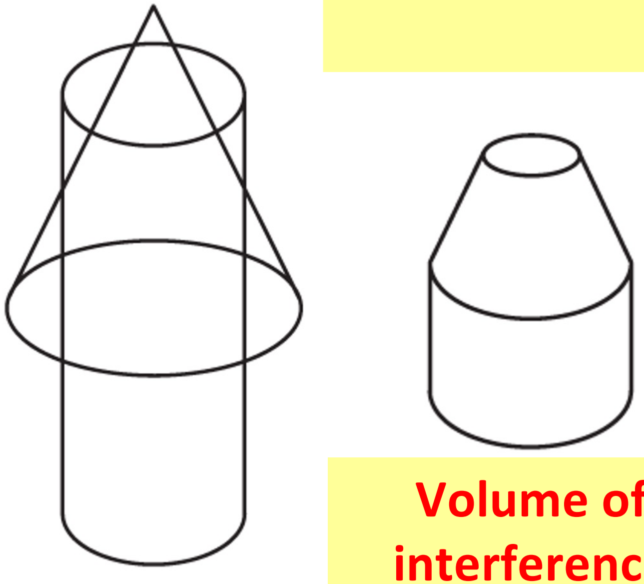


Overlapping Objects



Volume of interference

COMBINING SOLIDS



Overlapping Objects

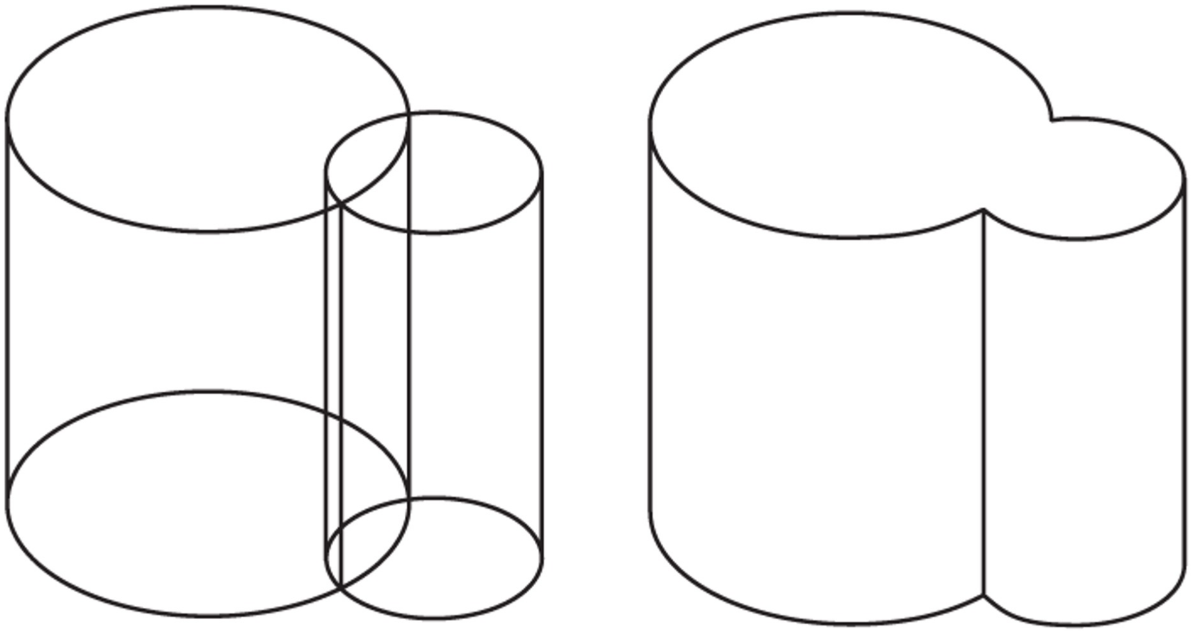
Volume of interference

Volume of interference takes shape and size characteristics from each of the two initial objects.

THE BOOLEAN JOIN OPERATION

When two objects are joined, the volume of interference is absorbed into the combined object.

The result is a single object that does not have "double" volume in the region of interference.



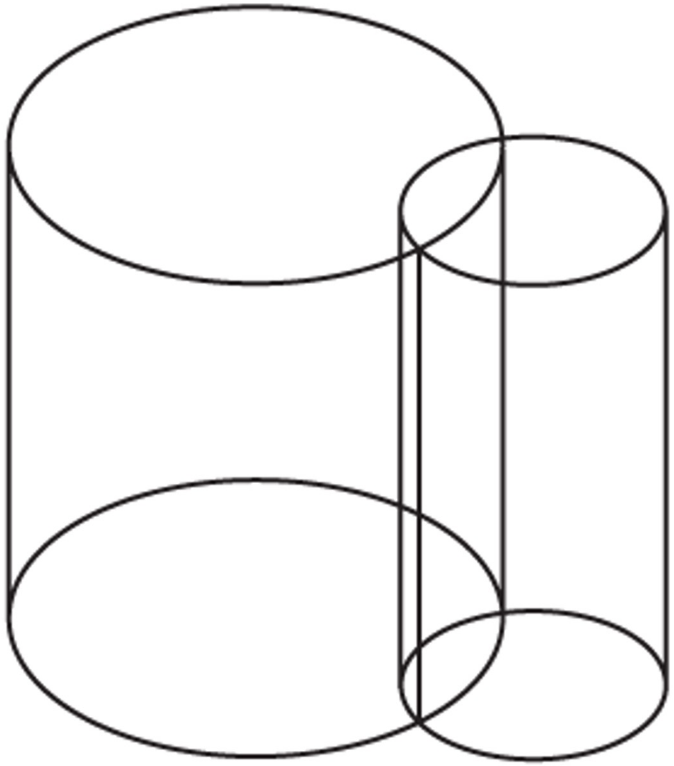
Overlapping Objects

Objects Joined

COMBINING SOLIDS

Result of two objects intersected

When two objects are combined by intersecting, the combined object that results from the intersection is the volume of interference between them



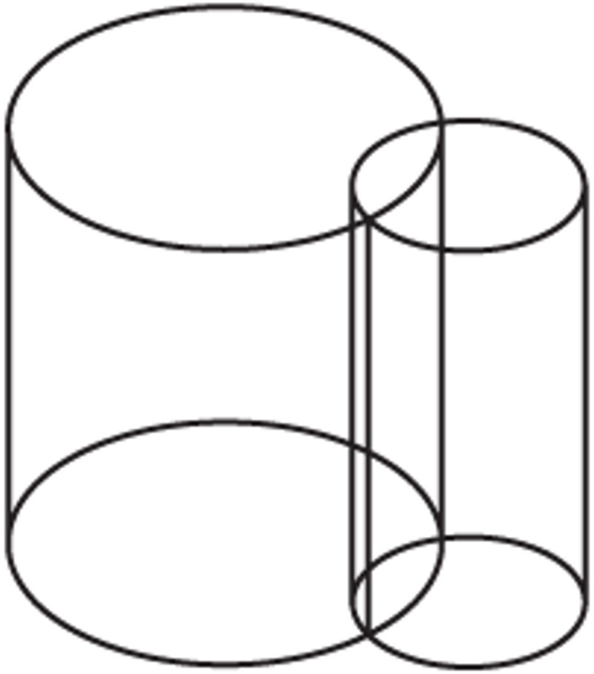
Overlapping Objects

Objects Intersected

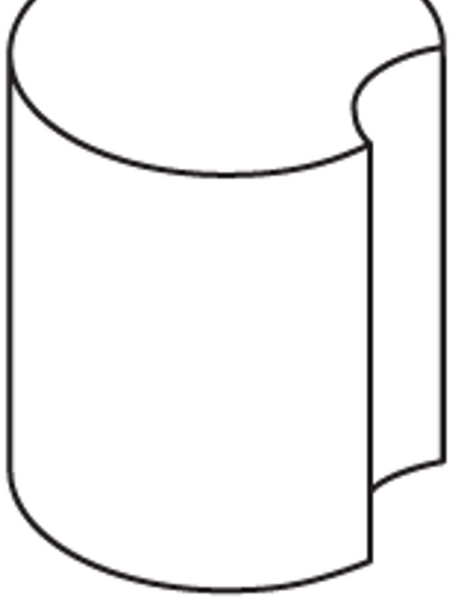
COMBINING SOLIDS

Result of two objects cutting

In the cutting of two objects, the combined object that results from the cutting depends on which object serves as the cutting tool and which object is cut by the other object. The result of a cutting operation is that the volume of interference is removed from the object that is cut,



Overlapping Objects



Small Cylinder Cuts Large Cylinder

Large Cylinder Cuts Small Cylinder

LABORATORY EXERCISE

- **Already the laboratory exercise questions are kept in the moodle**
- **Content of the material taught (taken from Lieu or Sorby) is in moodle**
- **You will be given the same questions when you come over to lab, you need to solve all of them without consulting your friends or teaching assistants**
- **Work on lab sheets independently. IT IS CONDUCTED LIKE A QUIZ. Do not copy from others.**
- **In case, if you are stuck and cannot make headway at all, your teaching assistant will help you but few marks would be deducted**

Best way is to

Study the material taught in the theory class – NOTES

Solve the laboratory sheet before coming to the lab class.

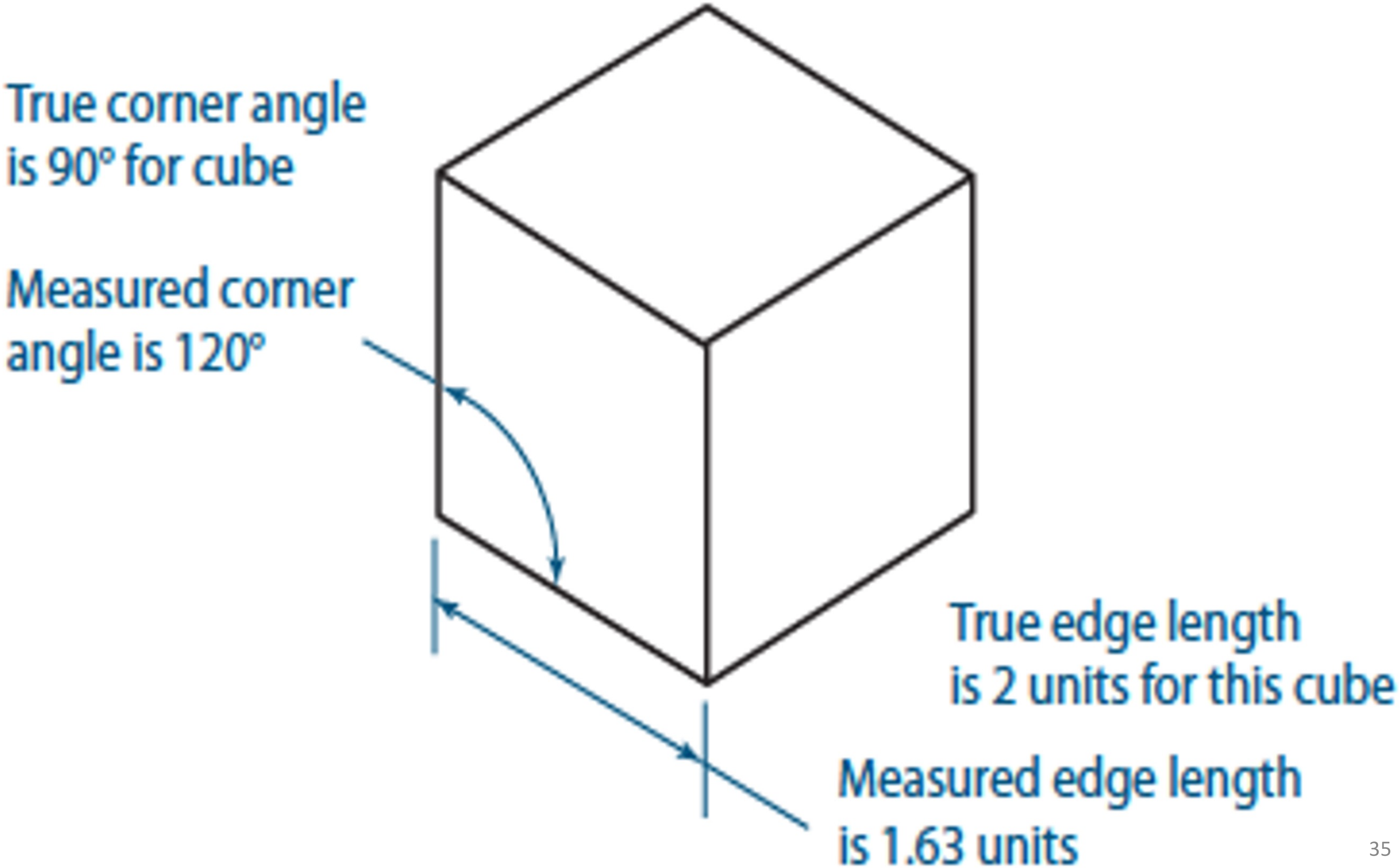
LABORATORY EXERCISE

- **Basis of evaluation of Lab submissions :**
  - **Effort**
  - **Correctness**
  - **Neatness**

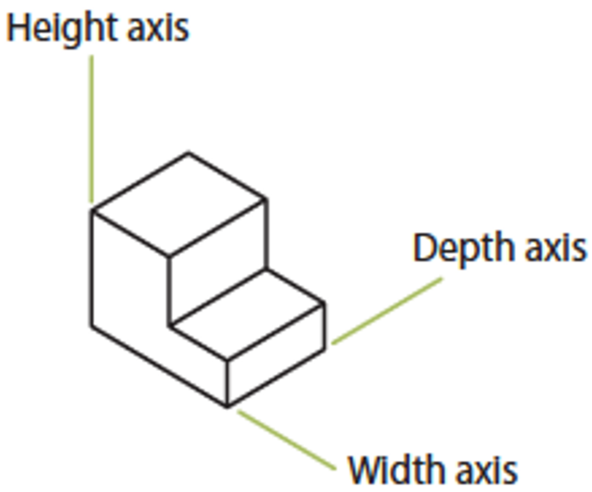
:

Extra reading on ISOMETRIC PROJECTIONS if interested

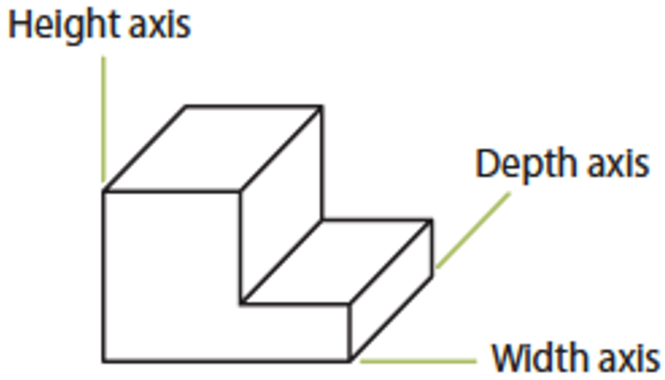
ISOMETRIC PROJECTION



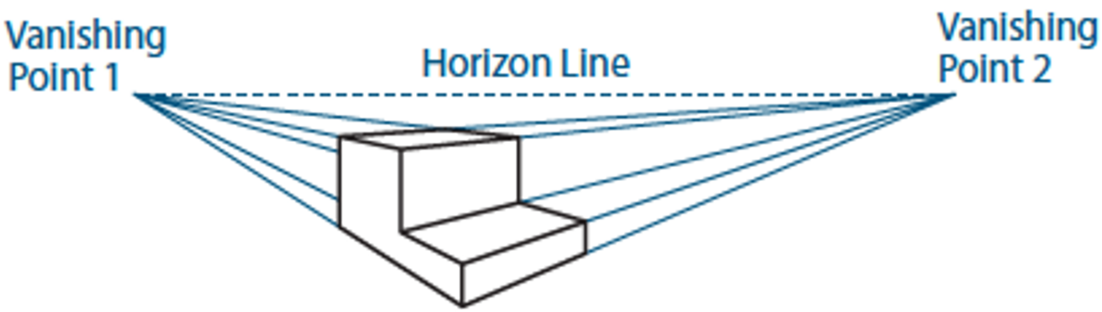
Axonometric refers to the angle that axes make with each other



AXONOMETRIC DRAWING

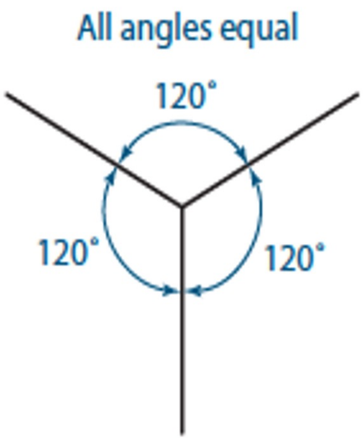


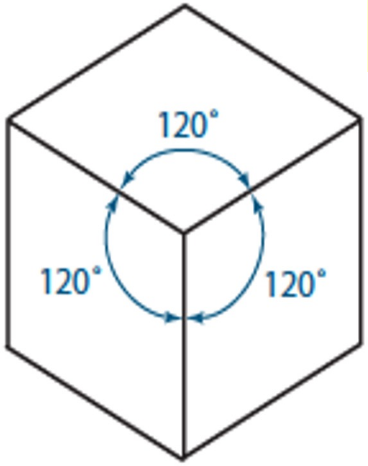
OBLIQUE DRAWING



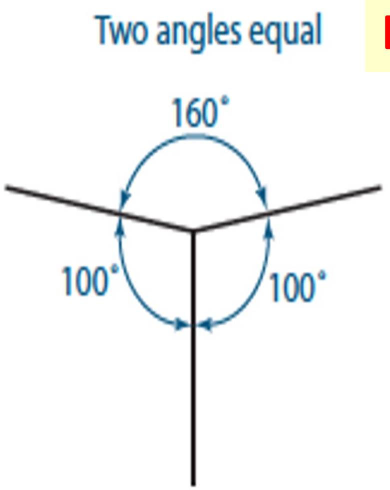
PERSPECTIVE DRAWING

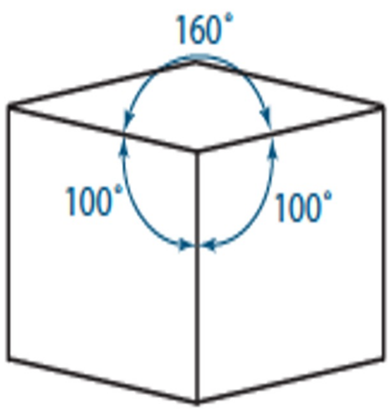
Isometric projection



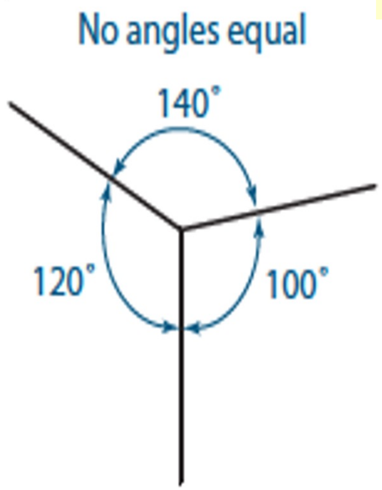


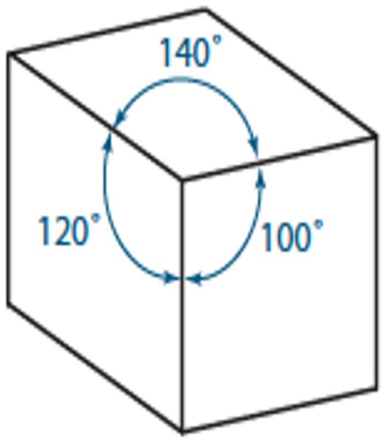
Dimetric projection





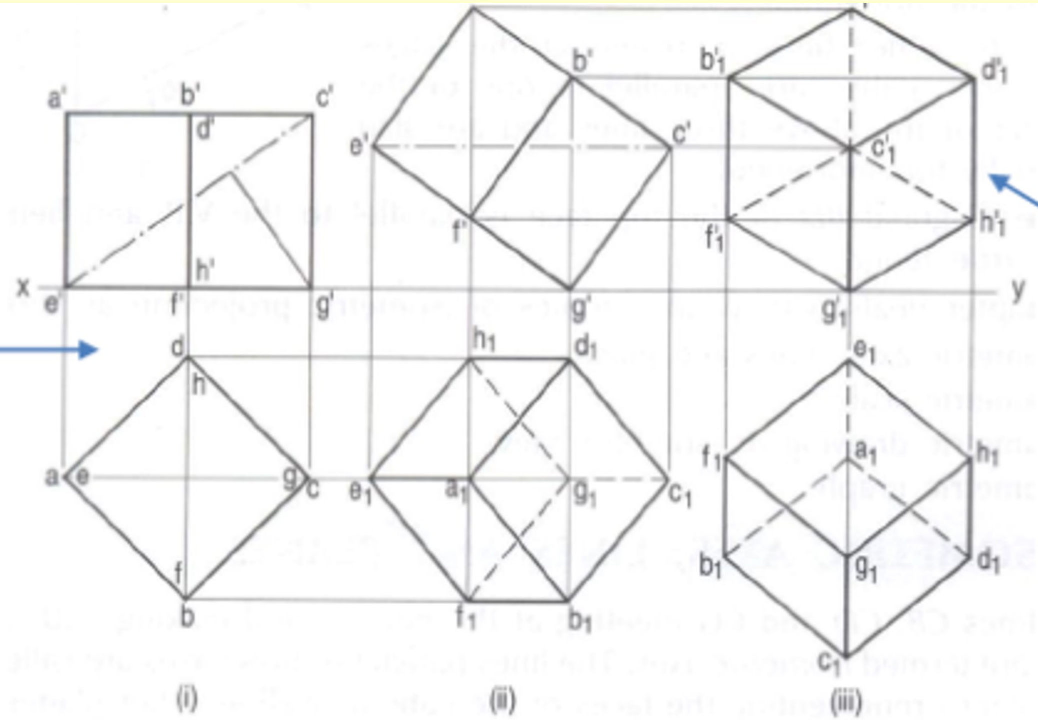
Trimetric projection





Before projecting the object onto V.P/H.P., if it is rotated about X/Y/Z axes by some arbitrary angle(s), more details of the object becomes visible as 2 or 3 faces of its bounding cube becomes visible. Such an orthographic view preceded by the rotation of the object is called axonometric projection. It is a pictorial view as it looks like a 3D view of the object

Orthographic Projection of Cube

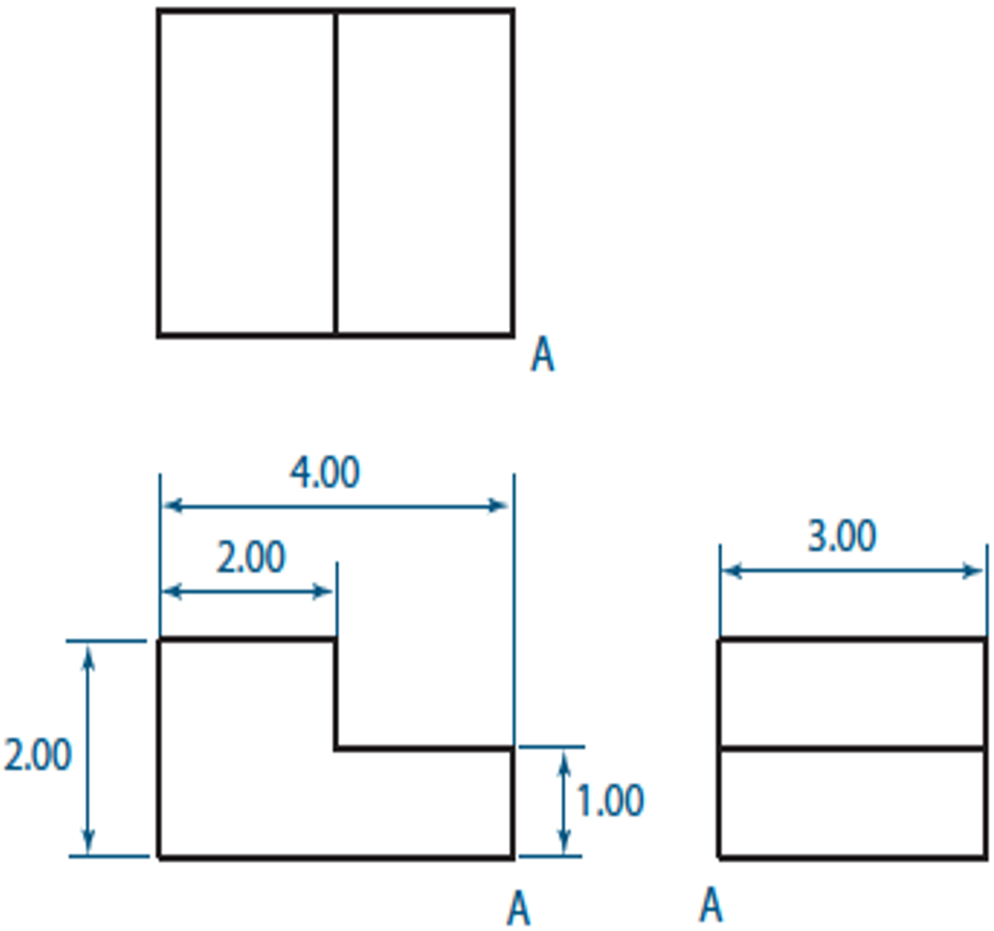


Axonometric (isometric) projection of cube

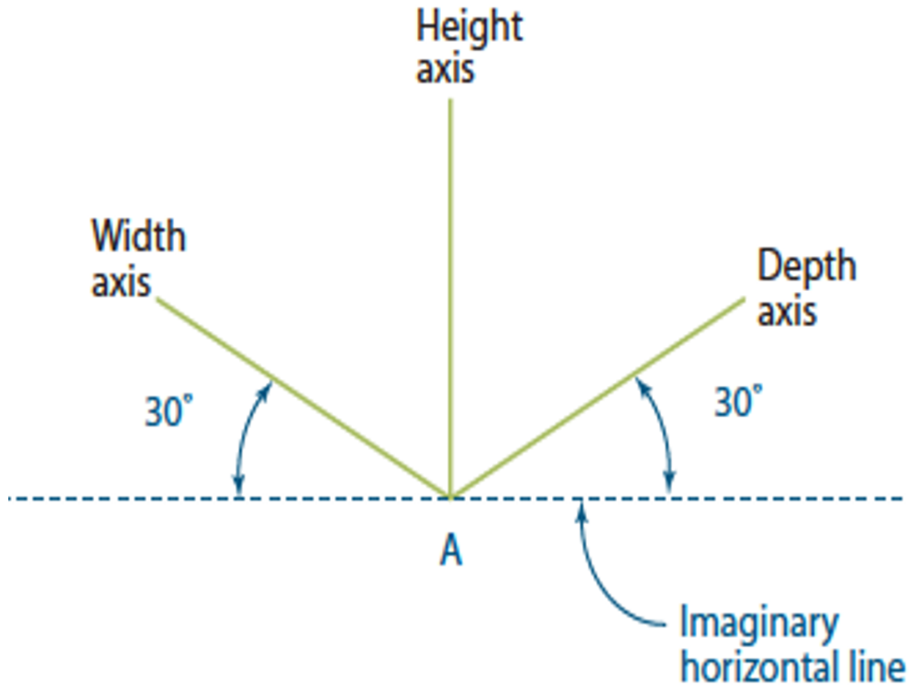
To draw the projections of a cube of 25 mm long edges resting on the ground on one of its corners with a solid diagonal perpendicular to the V.P., assume the cube to be resting on one of its faces on the ground with a solid diagonal parallel to the V.P.

Isometric drawing/view of a step block

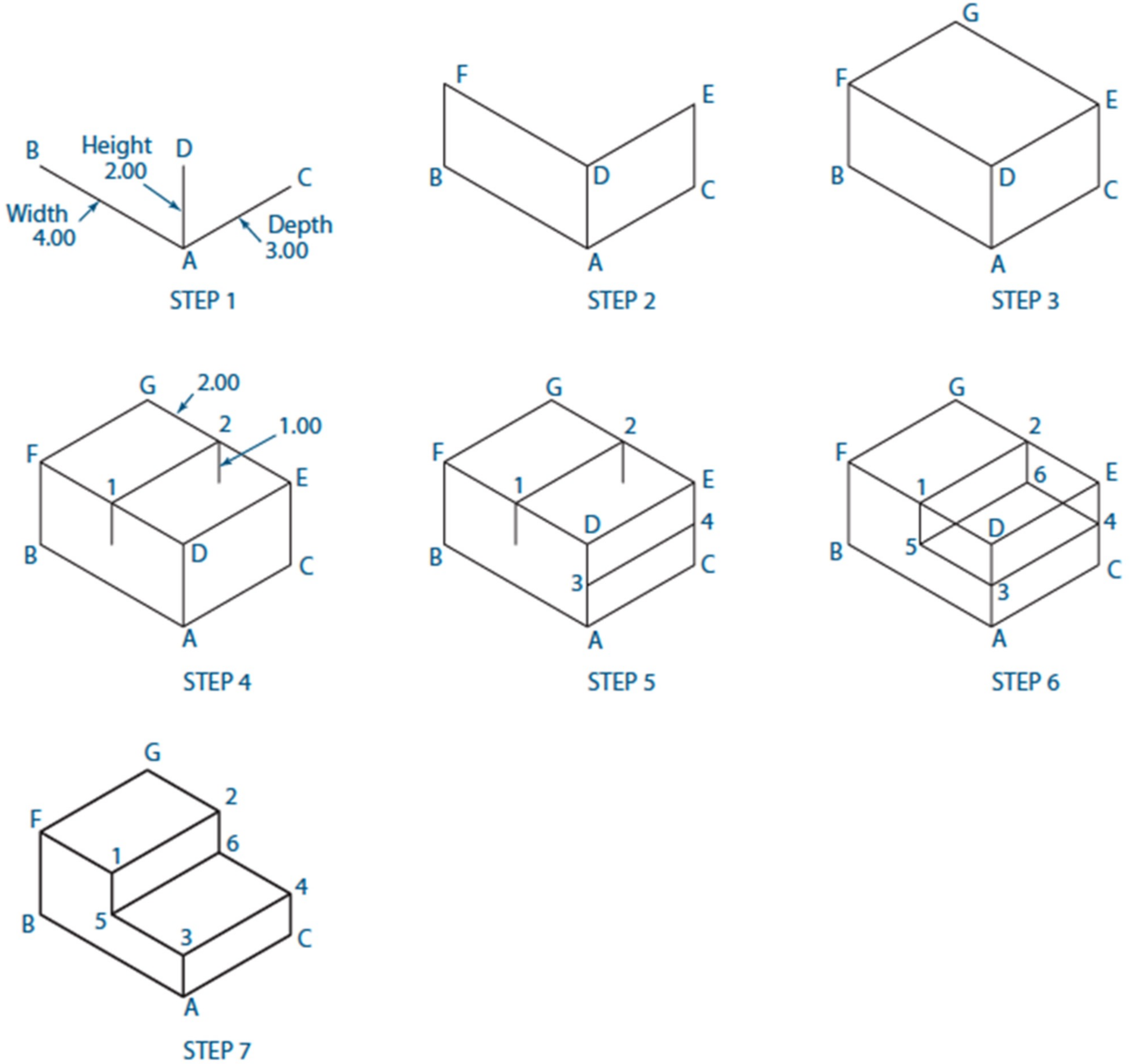
Orthographic views



Isometric axes

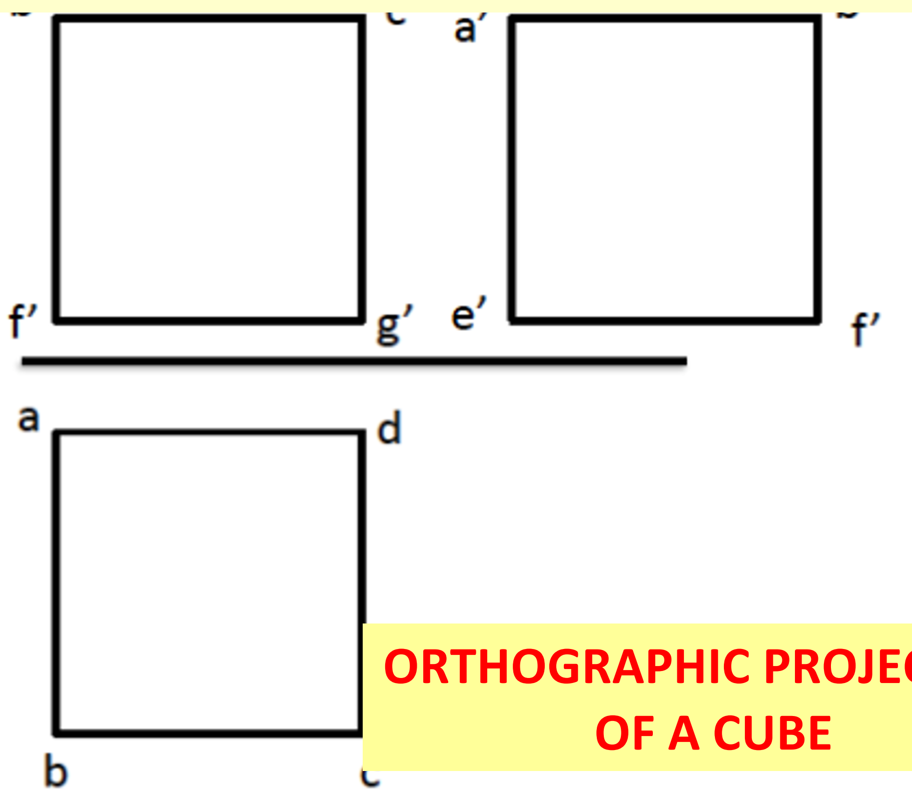


Isometric drawing of a step block



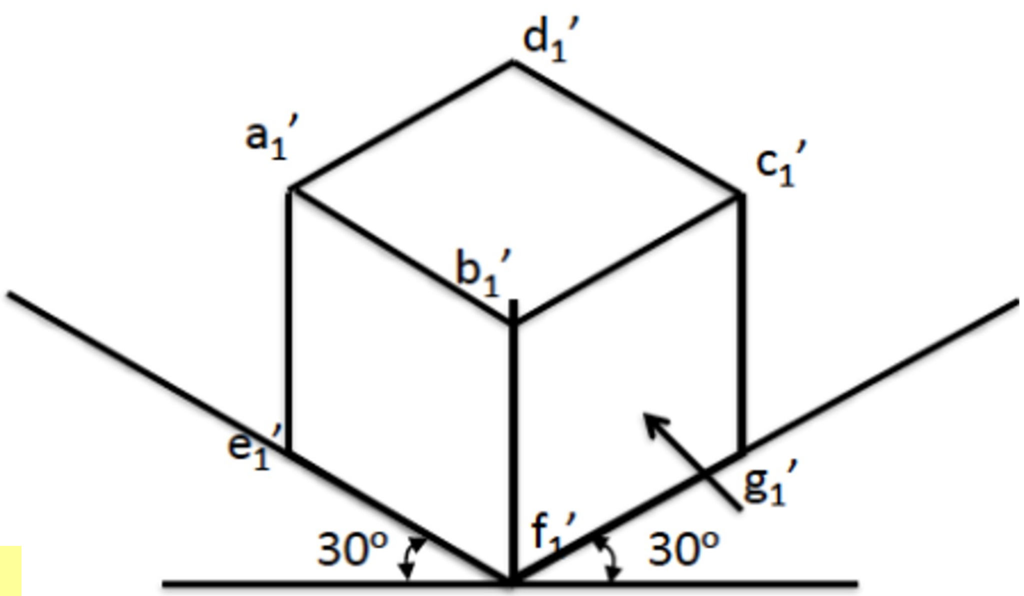
ISOMETRIC PROJECTION OF A CUBE

Draw the orthographic and the isometric projections of a cube with base parallel to the XY plane and the two adjacent faces parallel to the coordinate planes XZ and YZ.
The direction of viewing is normal to the XZ plane.

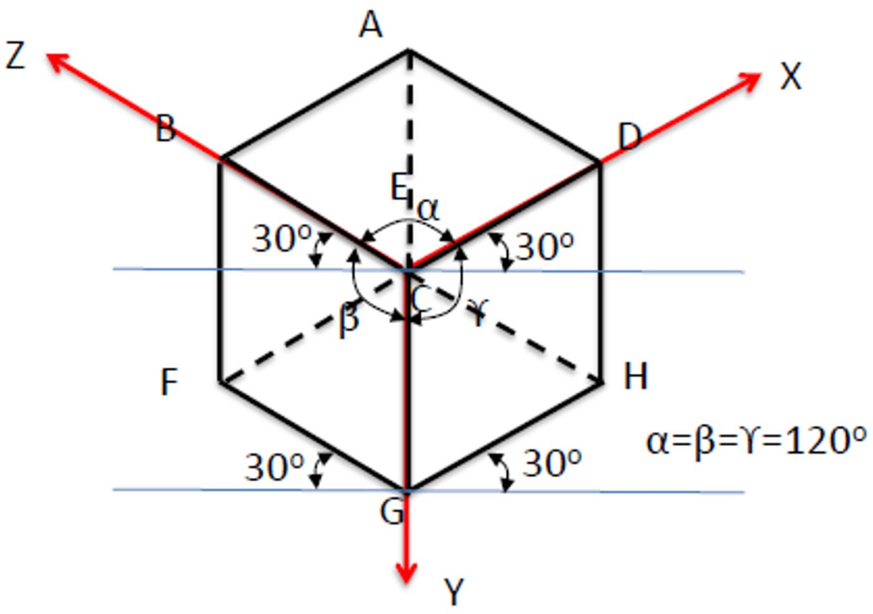


ORTHOGRAPHIC PROJECTION OF A CUBE

ISOMETRIC PROJECTION OF A CUBE



The length of all the sides which were parallel to the coordinate axes has decreased (foreshortened) equally



SOME FEATURES OF ISOMETRIC PROJECTION/VIEWS

The front edges - CB, CD and CG are called isometric axes

CG if for height, CD is for length (width) and CB is for width (length)

The three faces seen in the isometric projections are the same faces that will be seen in normal orthographic projections: top, front & side

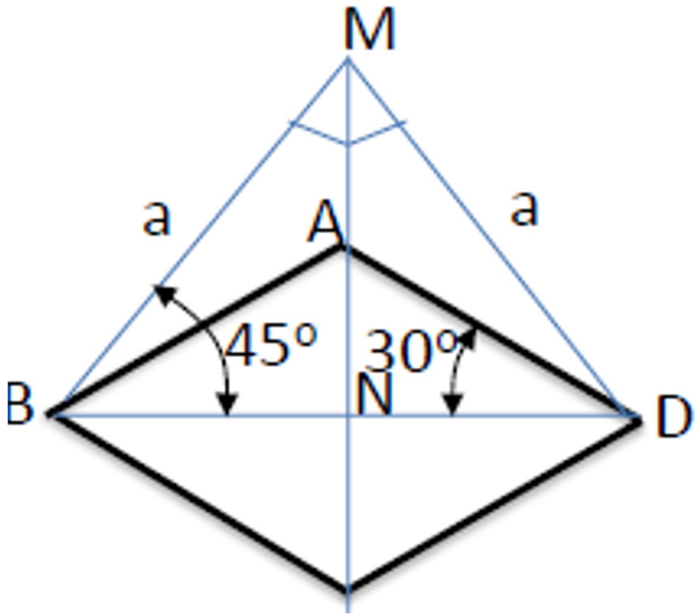
Lines parallel to the isometric axes are called isometric lines

Planes representing the faces of the cube and planes parallel to them are called isometric planes

The angles between the projections of these axes is equal (hence isometric) and is 120^o

90^o of the cube appear as either 60^o or 120^o

SOME FEATURES OF ISOMETRIC PROJECTION/VIEWS



$$\cos(45) = \frac{l(BN)}{l(BM)}$$

$$\cos(30) = \frac{l(BN)}{l(AB)}$$

$$\frac{l(AB)}{l(BM)} = \sqrt{\frac{2}{3}}$$

The projected length of an isometric line is $2/\sqrt{3}$ times the true length of the line

Lines which are not parallel to the isometric axis are called non-isometric lines
Non-isometric lines are not shortened in any fixed ratio, hence their lengths need to be found indirectly
Measurements should always be made on isometric lines and isometric axes only
Non-isometric lines are drawn by locating the position of their extremities on isometric planes and then connecting them