

## CHAPTER 3: TECHNICAL DRAWING

### 3.1 Introduction

This unit covers the competencies required to prepare and interpret technical drawings. It involves competencies to select, use and maintain drawing equipment and materials. It also involves producing plain geometry drawings, solid geometry drawings, pictorial and orthographic drawings and application of Computer Aided Design (CAD) packages.

### 3.2 Performance Standard

Use drawing equipment and materials according to task requirements, per workplace procedures and maintained as per manufacturer's instructions, waste materials are disposed in accordance with workplace procedures and environmental legislations, use personal protective equipment according to occupational safety and health regulations, produce plain geometry drawings, produce solid geometry drawings, produce pictorial and orthographic drawings of components and apply CAD packages in drawings according to standard drawing conventions and task requirements.


### 3.3 Learning Outcomes

#### 3.3.1 List of learning outcomes

- a) Use and maintain drawing equipment and materials
- b) Produce plain geometry drawings
- c) Produce solid geometry drawings
- d) Produce pictorial and orthographic drawings of components
- e) Apply CAD packages

### 3.3.2 Learning Outcome No 1: Use and Maintain Drawing Equipment and Materials

#### 3.3.2.1 Learning Activities

Learning Outcome No 1: Use and Maintain Drawing Equipment and Materials	
 Learning Activities	Special Instructions
1.1. Identify and gather drawing equipment 1.2. Use and maintain drawing equipment 1.3. Use drawing materials 1.4. Dispose waste materials 1.5. Use Personal Protective Equipment (dust coats, gloves and closed leather shoes)	<ul style="list-style-type: none"><li>• Demonstration</li><li>• Group discussion</li></ul>

#### 3.3.2.2 Information Sheet No3/LO1: Use and Maintain Drawing Equipment and Materials



##### Introduction

This learning outcome covers drawing equipment, drawing materials, maintenance of drawing equipment as per manufacturer's instructions as per workplace procedures. It also covers on how to dispose waste materials in accordance with workplace procedures and proper use of personal equipment. Use and maintain drawing equipment and materials.

##### Definition of key terms

**Drawing:** This is the use of lines, shapes, and sizes to construct objects or structures either in 2-dimesnional or 3-dimensional view.

**Technical drawing:** This is a precise detailed representation of an idea using symbols, lines, and signs in creating objects in the manufacturing of engineering articles.

**Drafting:** This is the act of producing a picture/sketch either in 2-dimesnional or 3-dimensional view and providing dimensions and notes. It is usually a quick sketch/presentation with details and not to scale.

**Designing:** This is the act of producing drawings to clearly define the requirements for concepts or products in order to be in line with the expected outcome.

**Maintenance:** It is an excellent means of improving the performance and condition of equipment and facilities.

**A maintenance program:** It is a comprehensive list of maintenance and its incidents.

**A maintenance schedule:** It is a list allocating specific maintenance of an area, including equipment and tools to a specific period.

**A maintenance checklist:** It is a list of maintenance tasks (preventive or predictive) typically derived through some form of analysis, generated automatically as work orders at a predetermined frequency.

### **Content/Procedures/Methods/Illustrations**

#### **1.1 Use and maintain drawing equipment as per manufacturer's instructions**

**Maintenance** is an excellent means of improving the performance and condition of equipment and facilities. An effective maintenance program identifies problems long before any equipment or facility breaks down or deteriorate. A good maintenance system presents the early discovery of problems, thus providing plenty of lead time for effective maintenance planning. The trainer has to value the importance of maintaining the training facilities, equipment and tools s/he is using or under his/her care if he values the presence and availability of these resources for effective training and learning processes. Training equipment is usually placed in the practical work area or the trainees' resource area. The sizes and uses of equipment vary in the different training qualifications and generally classified into five (5):

- a) Large items of equipment; motor vehicles, industrial sewing machines
- b) Small items of equipment
- c) Simple equipment; electric fan, floor polisher
- d) Complex equipment; plasma cutting machine, simulator (automotive)
- e) Equipment with significant health and safety implications; duplicator machine

#### **Reasons for maintenance**

- To extend the useful life of physical facilities
- To assure the operational readiness of installed equipment and maximum possible return on investments
- To properly discard hazardous wastes
- To ensure the safety of personnel using the facilities, physical properties and the environment

### **Importance of maintenance**

- Improved morale of human resources
- Reduced operational cost
- Increased production
- Prolonged life of facilities
- Prompt delivery of services/product
- Waste/garbage reduction
- Ensured safe environment

### **Ways of implementing a maintenance program**

The question on how do we implement the maintenance program will centre on the 5Ms as follows:

- Manpower
- Money (financial resources)
- Methods and system
- Machines (facilities)
- Materials and supplies

### **Tools and equipment used in technical drawing**

#### **i. Drafting Tables/board**

Draftsmen create technical drawings using a tilting table. Parallel rulers on each side of the drawing surface align the drawing paper and provide horizontal and vertical guides for drawing.



Figure 10. Drafting tables

Source: [www.wayfair.com](http://www.wayfair.com)

#### **ii. Curve Templates and Compasses**

Draftsmen create curves using irregular curve templates made of clear rigid plastic. They draw circles and portions of circles called arcs with an adjustable compass and calculate angles from 1 degree to 180 degrees with clear plastic protractors.

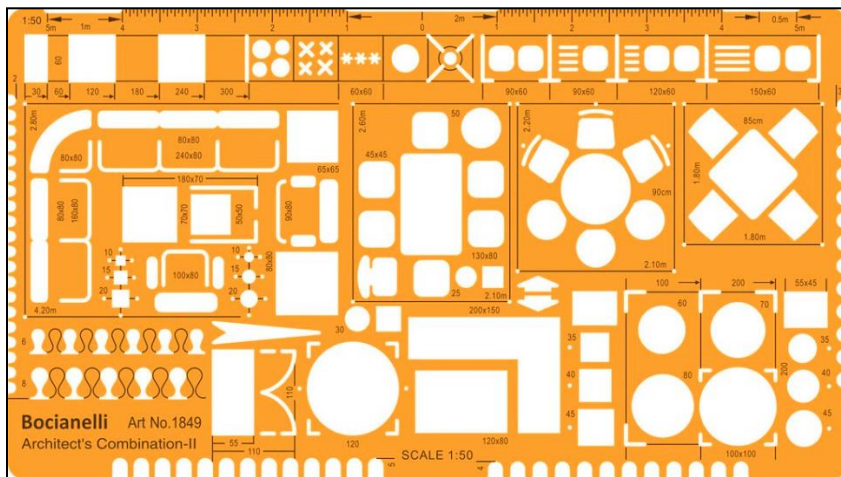


Figure 11. Drawing templates.  
Source: [www.bocianelli.com](http://www.bocianelli.com)

### Caliper and Vernier Scale

A caliper is a tool which is used for a measurement of some objects



Figure 12. Caliper and vernier scale  
Source: [www.amazon.com](http://www.amazon.com)

### Drawing Compass

A drawing compass is a tool for drawing circles on a specific material but also for navigational help and measuring distances

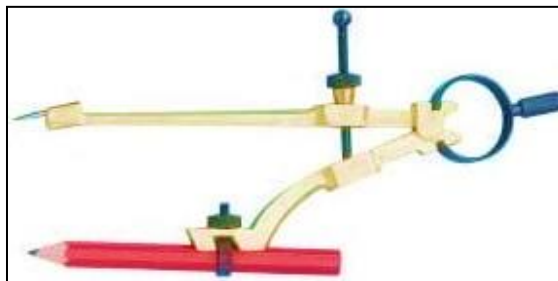


Figure 13. Drawing compass.  
Source: [www.amazon.com](http://www.amazon.com)

## **Types of Drawing Compasses**

### **Beam Compass**

A beam compass is made of brass or wooden beam, and it is used for drawing circles that are larger than those made by regular compass.

### **Scribe Compass**

This type of compass is the simplest by form. It is used by carpenters to scribe a circle instead of drawing it.

### **Loose Leg Divider**

It is also used to scribe circles. Loose leg wing dividers also provide stepping off repetitive measurements with particular accuracy.



Figure 14. Loose leg divider

Source: [www.amazon.com](http://www.amazon.com)

### **Proportional Compass**

It is a tool consisting of two rulers which are equal length and joined by a hinge.

#### **iii. Lettering Guides**

Lettering templates guide the draftsman in the execution of uniform lettering throughout the drawing. As a matter of common practice most creators of technical drawings hand letter in personally developed styles that identify their work as clearly as fingerprints.

#### **iv. Drawing Pencils**

Most draftsmen use sharp 2H and 4H pencils for drawing. Pencils may be wooden or mechanical pencils with replaceable leads. They utilize erasing shields and soft gum or nylon erasers to make corrections.

#### **v. Inking Pens**

Technical drawings created in pencil are usually over-traced with ink to render durable final drawings. Early inking pens consisted of a mechanical device with an adjustable nib. Modern disposable inking pens have built in ink reservoirs and are available in many point widths.

## Pencils

Pencil is used to draw on the paper. Any type of pencil is not suitable for drawing. There are some limitations, the drawing appearance should be very neat and understandable. Every line of the drawing should indicate its importance. It depends upon the hardness of the pencil. Based on the hardness quality pencils are classified into 18 grades and they are as shown in the table below:

Table 2: Classification of pencils

<b>Grade of Pencil</b>	<b>Hardness of Pencil</b>
<b>9H</b>	Hardest
<b>6H, 5H, 4H</b>	Extremely Hard
<b>3H</b>	Very hard
<b>2H</b>	Hard
<b>H</b>	Moderately hard
<b>F</b>	Firm
<b>HB</b>	Medium hard
<b>B</b>	Moderately soft and black
<b>2B</b>	Soft and black
<b>3B</b>	Very soft and black
<b>4B, 5B, 6B</b>	Very soft and very black
<b>7B</b>	Softest

Out of the above 18 grades of pencils, the following grades are used in engineering drawings.

Table 3: Uses of engineering pencil grades

Grade of Pencil	Used to Draw
<b>3H</b>	Construction lines
<b>2H</b>	Dimension lines, center lines, sectional lines, hidden lines
<b>H</b>	Object lines, lettering
<b>HB</b>	Dimensioning, boundary lines



Figure 15: Pencil grades  
Source: www.amazon.com

#### vi. Drafting Machines

Modern drafting machines combine horizontal and vertical rulers or scales and a protractor head that allows adjustment of the rulers to required angles for drawing. The device is permanently attached to the drawing board and uses a pair of connected arms to move freely around the drawing surface.

#### vii. CAD: Computer Aided Design

Drawings and designs using computer software drastically reduce hand and machine drafting, especially in the professional sectors. Lower drawing cost and greater degrees of accuracy dictate increasing use of CAD as a primary tool for creating technical drawings. Large computer screens for creating designs and plotters for printing large technical drawings are replacing traditional technical drawing tools. Colleges and trade schools offer CAD training to a growing number of specializing technicians who are replacing conventional draftsmen in the drafting room.



### viii. Rulers and Squares

Using a T-square and clear plastic triangle, draftsmen create lines. Common triangles they use are an eight-inch triangle with forty-five- and ninety-degree sides and a ten-inch triangle with 30- and 60-degree sides. Draftsmen measure dimensions with triangular shaped rulers that have different scales on each of three surfaces.

A **ruler** is an instrument that can be used for measuring distances or to draw straight lines in printing, geometry, technical drawing and many other things.



Figure 16: Rulers and squares

Source: [www.amazon.com](http://www.amazon.com)

The **protractor** is an instrument used for measuring angles. It is usually made of transparent glass or transparent plastic

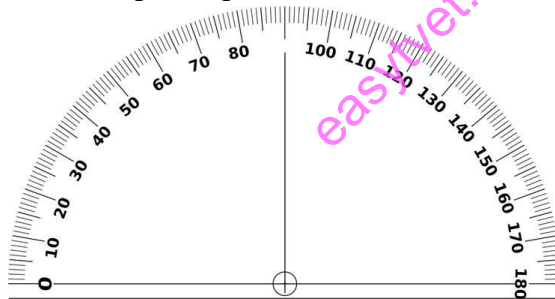


Figure 17: Protractor

Source: [www.amazon.com](http://www.amazon.com)

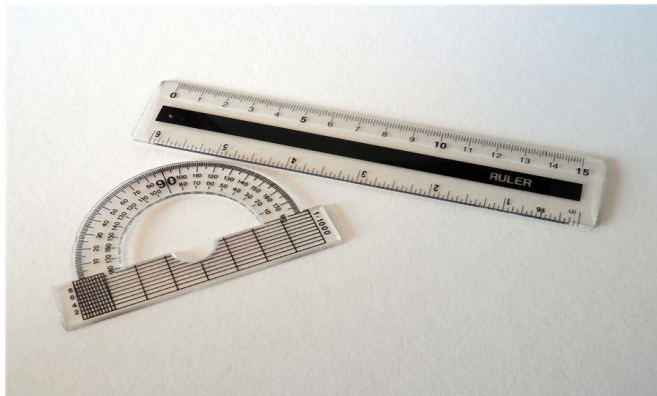


Figure 18: Protractor and a ruler

Source: [www.amazon.com](http://www.amazon.com)

### Mini Drafter

Mini drafter is an instrument which can be used for multiple functions in drawing. It contains two arms which is adjustable to required angle and at the end of the lower arm a scale set is attached.



Figure 19: Mini drafter

Source: [www.vectorstock.com](http://www.vectorstock.com)

### T-Square

A T-square is used to draw horizontal and vertical lines on drawing sheet. It is made of wood or plastic and in T shape. The vertical part of T is called as blade and horizontal part of T is called as head.



Figure 20: T-square

Source: [www.amazon.com](http://www.amazon.com)

### Set Squares

Set squares are used to draw lines with an angle between them. In most of the structures, 30, 45, 60 and 90-degree lines are most common. So, set squares make the work easier for this type of drawings.

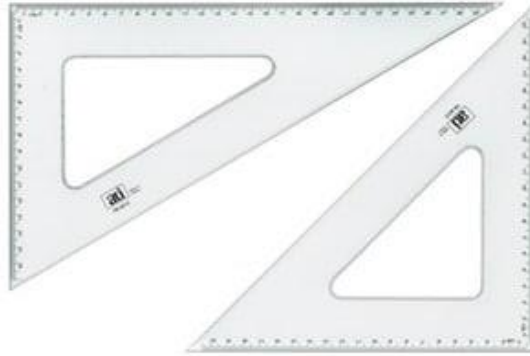


Figure 21: Set square  
Source: [www.vectorstock.com](http://www.vectorstock.com)

### French Curves

French curves are made of plastic and they are in irregular shapes. Sometimes the drawing requires irregular curves or shapes or arcs which cannot be drawn using compass. In that case French curves are suitable.

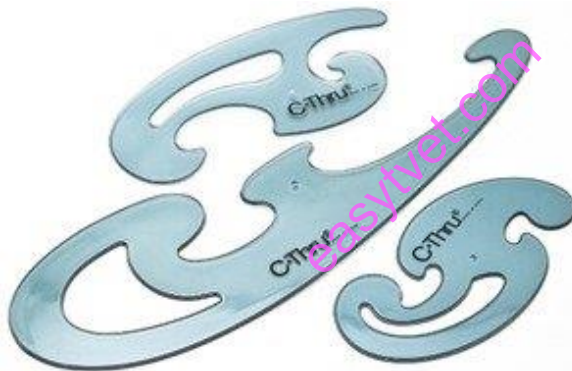


Figure 22: French curve  
Source: [www.goldstartool.com](http://www.goldstartool.com)

### Drawing Sheet

Drawing sheet is a white paper on which an object is drawn which is available in various sizes. The sheet used for engineering should be of good quality. It should be white in color with uniform thickness which must resist the easy torn of paper. The surface of sheet must be smooth.

### Eraser

Eraser is used to remove the lines or spots which were drawn by mistake or with wrong measurements. The eraser used should be of good quality and soft. It should not damage the paper while erasing.

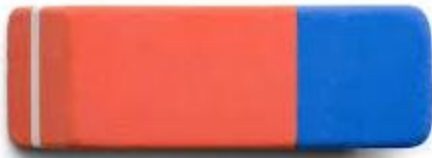


Figure 23: Eraser

Source: [www.shutterstock.com](http://www.shutterstock.com)

### **Paper Holders**

When the drawing sheet is placed on the board it may not be in fixed position. To fix the drawing sheet to the board paper holders are used.



Figure 24: Paper holder

Source: [www.shutterstock.com](http://www.shutterstock.com)

Disposing of waste materials so as to prevent air pollution is a recent requirement in the history of waste disposal. Proper disposal of waste resulting from technical drawing must be followed. Degradable waste must be disposed separately with non-degraded waste. Broken compasses and rules must be disposed properly as they can cause harm to the trainee in the work place. Personal protective equipment, or PPE, is designed to protect you from hazards found on or off the job. The PPE prevent the draftsmen from hazards when they are working in the drawing rooms. These PPE include:

- Grooves
- Closed shoes
- Dust coat
- Helmets

Proper procedures must be observed and adhered to know when to put on the protective gears to minimize injuries during and after the exercise.

## Conclusion

The learning outcome covered or equipped the learner with drawing equipment, drawing materials used and maintenance of drawing equipment, drawing materials, dispose of waste materials, and proper use of productive equipment in accordance with workplace procedures and environmental legislations.

## Further Reading



1. Engineering drawing by K. Venugopal. Published by: New Age International (p) limited (2016).
2. Engineering drawing + Auto CAD. By: Venugopal. K PUBLISHED BY New Age International pvt ltd

## 3.3.2.3 Self-Assessment



### Written Assessment

1. The accuracy of the drawing depends on \_\_\_\_\_.
2. Which of the following instrument is made of thin strips of wood arranged in a line to form a rectangle and on which, the drawing is made?
  - a) Mini-drafter
  - b) Drawing Board
  - c) Protractor
  - d) Scale
3. Which of the following tools is used to draw horizontal lines?
  - a) Mini – drafter
  - b) Protractor
  - c) T – square
  - d) French curve
4. Which of the following instruments can be used to draw accurate perpendicular lines, parallel lines and angular lines?
  - a) Mini-drafter
  - b) T-square
  - c) Protractor
  - d) Set square

5. According to the Indian Standard Institute (ISI), which among the following designation has the size 1000 x 700 (in mm)?
  - a) B0
  - b) B1
  - c) B2
  - d) B3
6. Which is the most common tool used for drawing circles?
  - a) French curve
  - b) Mini – drafter
  - c) Divider
  - d) Compass
7. For drawing circles with a large radius, which of the following tool is used?
  - a) Bow compass
  - b) Lengthening bar compass
  - c) Divider
  - d) Protractors
8. The preferred size of the drawing sheets is recommended by the \_\_\_\_\_
  - a) B.I.S.
  - b) ASME
  - c) ASTM
  - d) NIST
9. SP: 46 (2003) recommends the borders of \_\_\_\_\_ mm width for the sheet sizes A0 and A1, and \_\_\_\_\_ mm for the sizes A2, A3, A4 and A5.
  - a) 10, 20
  - b) 15, 20
  - c) 20, 10
  - d) 15, 10
10. The false statement regarding orientation mark.
  - a) The orientation mark coincides with one of the centering marks
  - b) Represents the direction to which sheet is placed
  - c) Orientation mark can be used for the orientation of drawing sheet on the drawing board
  - d) Facilitate positioning of the drawing for reproduction purpose
11. Select and apply different drawing paper holders
12. Discuss the best methods of drawing waste materials disposal which is environmentally friendly.
13. State three importance of drawing tools maintenance

### **Oral Assessment**

1. State two uses of protractors in technical drawing
2. Give two types of pencils used to make faint lines

### **Practical Assessment**

Make a sketch of a CAD design

#### **3.3.2.4 Tools, Equipment, Supplies and Materials**

- Drawing room
- Computer lab
- Drawing equipment and materials
- Computers
- CAD package
- Overhead projector

#### **3.3.2.5 References**




Hubka, V. (2015). Principles of engineering design. Elsevier.

Morling, K. (2010). Geometric and engineering drawing. Routledge.

Shrock, C. R. (2009). Advanced AutoCAD 2010 Exercise Workbook. Industrial Press Inc.

### 3.3.3 Learning Outcome No 2: Produce Plane Geometry Drawings

#### 3.3.3.1 Learning Activities

Learning Outcome No 2: Produce Plain Geometry Drawings	
 Learning Activities	Special Instructions
<p>2.1 Identify different types of lines used in drawing and their meanings</p> <p>2.2 Construct different types of geometric forms (circles, triangles, rectangles, parallelogram, polygons, pyramids, conic sections, prisms, loci)</p> <p>2.3 Construct different types of angles</p> <p>2.4 Measure different types of angles using appropriate measuring tools.</p> <p>2.5 Bisect angles</p> <p>2.6 Conduct freehand sketching of different types of geometric forms, tools, equipment and diagram.</p>	<ul style="list-style-type: none"><li>• Use correct tools (drawing and measurement)</li><li>• Demonstrations and group discussion</li><li>• Use the correct dimensions</li></ul>

#### 3.3.3.2 Information Sheet No3/LO2: Produce Plain Geometry Drawings



##### Introduction

This outcome covers a variety of plain geometry drawings that include lines, triangles, quadrilaterals, polygons, dimensioning and drawing rules, bisecting angles according to standard and measurement of different types of angles.

##### Definition of key terms

**Drawing instruments:** These are the tools/equipment that are essential in producing drawings.

**Drawing materials:** These are consumables that are utilized in technical drawing.

**Plane geometry:** This type of geometry involves production of drawings in two dimensions.

**Solid geometry:** Solid geometry involves production of drawings in three dimensions.



## Content/Procedures/Methods/Illustrations

### Plane geometry principle

A line projects as a true length when a view is taken looking perpendicular to the line. A line parallel to the vertical plane will appear as a true length in elevation. A line parallel to the horizontal plane will appear as a true length in plane. Parallel lines appear parallel in every orthographic view. If a line is parallel to any line on a plane, it is parallel to the plane. A line projects as a point when we look along its true length. A plane projects as an edge when any line on the plane projects as a point. The true shape of a plane is seen on a projection plane which is parallel to the plane. Two planes intersect in a line.

### Line

A geometric primitive that has length and direction, but no thickness. It may be straight, curved or a combination of these. Lines also have important relationship or conditions, such as parallel, intersecting, and tangent. Specific length and non-specific length. Straight line that extends to infinity from a specified point.

### Relationship of one line to another line or arc

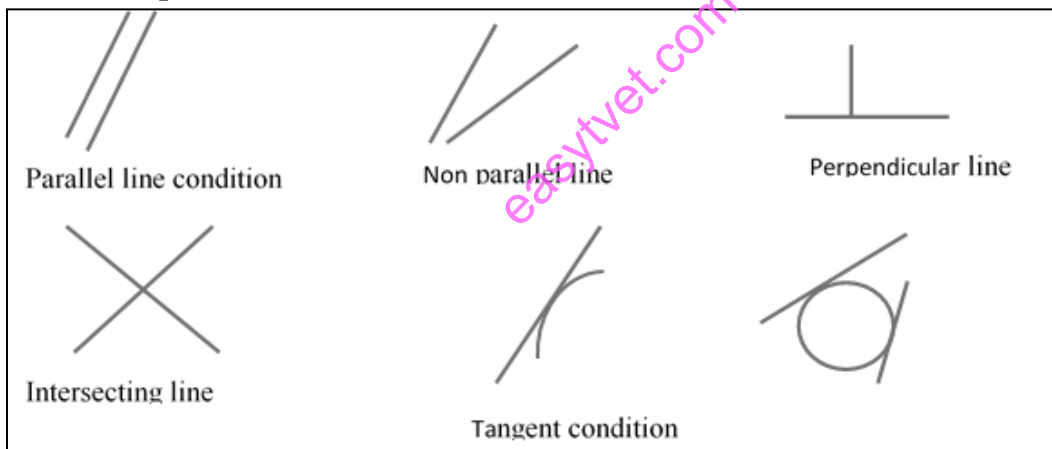


Figure 25: Lines

### Bisecting a line

#### Steps

##### a) Preparing the Compass

- i. Draw the line segment you need to bisect. If the line segment is not already given, you will need to make it using a straightedge.

Figure 26: Drawn line

- ii. Choose an appropriately sized compass. If you open the compass completely, and its span is one-half the length of the line or less, you need to choose a bigger compass.

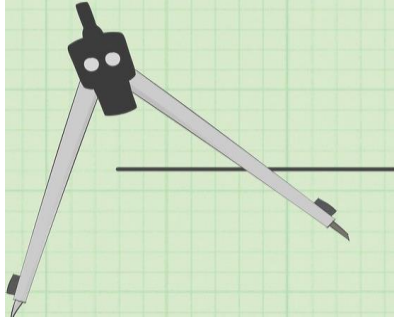


Figure 27: Open Compass  
Source: alamy.com

- iii. Position the compass on an endpoint. To do this, place the needle of the compass on either endpoint. Open the compass so that it spans a little more than half the length of the line

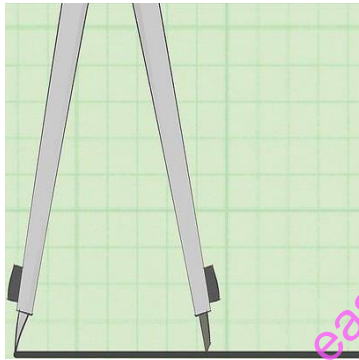


Figure 28: Compass Position  
Source: www.alamy.com

**a) Bisecting the Line**

- i. Draw an arc above and below the line segment. Make sure the needle stays on the endpoint, and that you do not adjust the compass setting. The length of the arcs does not matter.

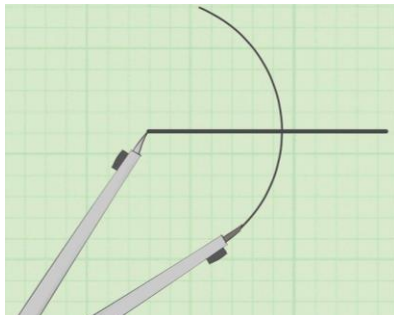


Figure 29: An arc  
Source: www.alamy.com

- ii. Reposition the compass on the other endpoint. Make sure you do not change the compass setting.

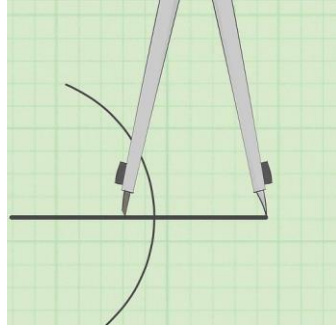


Figure 30: End point Position  
Source: [www.researchgate.com](http://www.researchgate.com)

- iii. Draw another set of arcs, above and below the line segment. Make sure the needle stays on the endpoint, and that you do not adjust the compass setting. The two sets of arcs you've drawn should intersect.

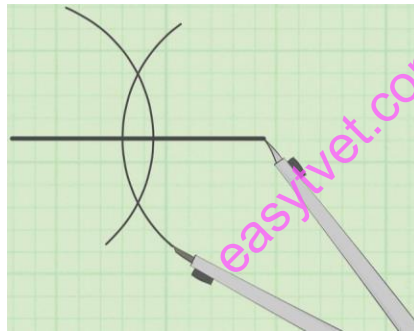


Figure 31: Arcs above and below line segment  
Source: [www.researchgate.com](http://www.researchgate.com)

- iv. Connect the arc intersections. To do this, place your straightedge on the point where the arcs above the line intersect, and align it with the point where the arcs below the line intersect.

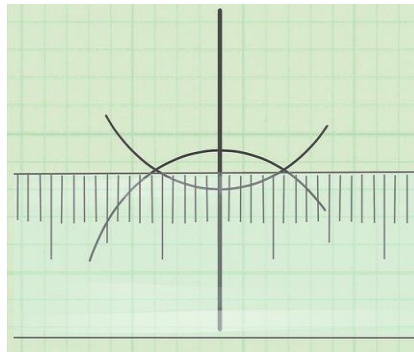


Figure 32: Connected arc intersections  
Source: [www.alamy.com](http://www.alamy.com)

- v. Draw your perpendicular bisector. The line you draw between the two arc intersections bisects the line at a ninety-degree angle.

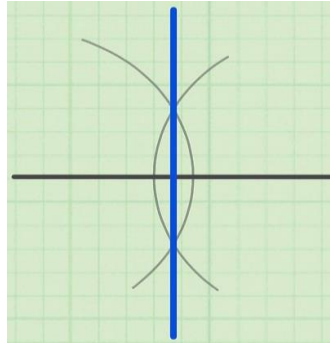


Figure 33: Perpendicular line  
Source: [www.shutterstock.com](http://www.shutterstock.com)

- vi. Understand why this works. You have used the compass to outline two congruent circles centered over either endpoint. The intersecting arcs represent the endpoint of a radii from the center of either circle. The length of the radii will be the same since the circles are of the same size.

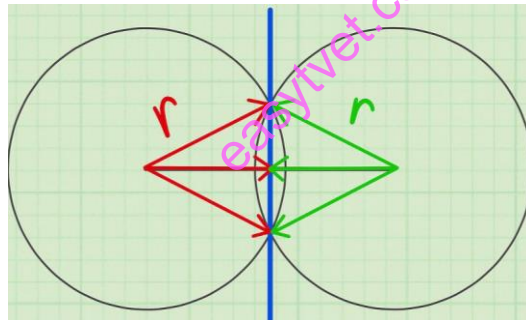


Figure 34: Completed Drawing  
Source: [www.alamy.com](http://www.alamy.com)

### Plane Geometry

Plane geometry can take various shapes.

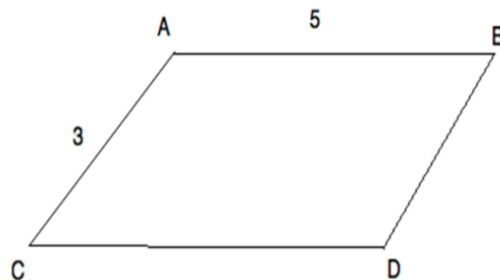


Figure 35: Plane Geometry  
Source: [www.earthslab.com](http://www.earthslab.com)

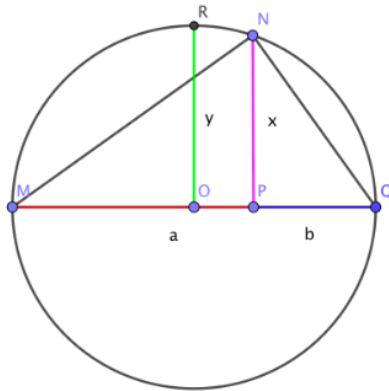


Figure 36: Plane Geometry  
Source: www.earthslab.com

### Conclusion

This outcome covered plane geometry drawings i.e. types of lines, polygons, triangles, quadrilaterals, dimensioning and drawing rules

### Further Reading



1. K Morling geometric and engineering drawing
2. Hubka, V. (2015) Principles of engineering design, Elsevier
3. Davies, B. L., Robotham, A. J., & Yarwood, A. (1991). Computer-aided drawing and design. London: Chapman & Hall.

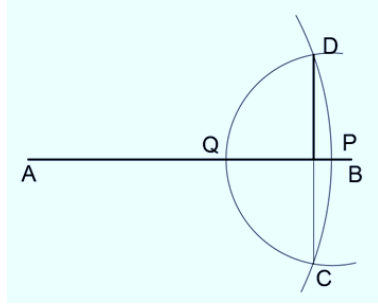
### 3.3.3.3 Self-Assessment



#### Written Assessment

1. While drawing a perpendicular to a line from a point within the line but nearer to the end of the line, all the arcs drawn in the process are of \_\_\_\_\_?
  - a) Different radii
  - b) Different radii but one
  - c) Same radii but one
  - d) Same radii

2. In the given figure which of the following construction line is drawn first?

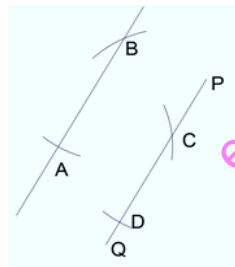


- a) Line AP
- b) Arc DPC
- c) Arc DQC
- d) Line DC

3. For drawing parallel lines to a given line through a given point we make use of \_\_\_\_

- a) Arcs
- b) Triangles
- c) Lines
- d) Quadrilaterals

4. Which of the following arcs is made first to draw a parallel line to the given line PQ?



- a) A
- b) B
- c) C
- d) D

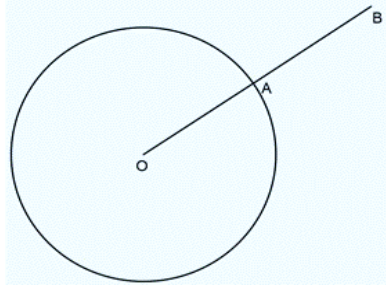
5. A tangent to a circle is a line which touches the circle at one and only one point.

- a) True
- b) False

6. The line perpendicular to a tangent and is passing through the point of contact is called \_\_\_\_\_

- a) Perpendicular bisector
- b) Angle bisector
- c) Normal
- d) Tangent

7. In the following figure, the tangent at point A can be drawn by \_\_\_\_\_

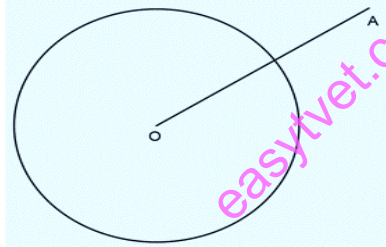


- a) Angle bisector
- b) Perpendicular bisector
- c) Rectangle
- d) Arc

8. How many tangents can be drawn from a point outside a given circle?

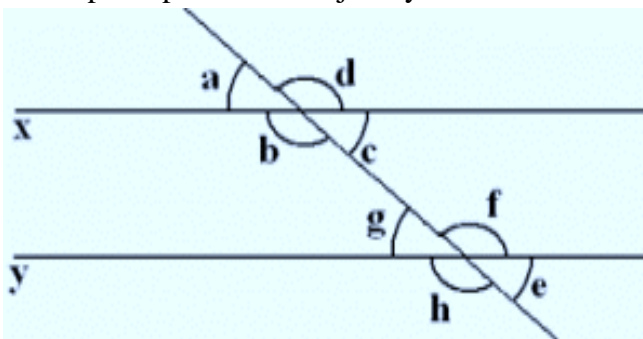
- a) 4
- b) 3
- c) 2
- d) 1

9. In the following figure, how will you make a tangent from the point outside the circle?



- a) By drawing a semicircle with diameter as OA
- b) By drawing a perpendicular bisector
- c) By drawing an angle bisector
- d) By drawing circle with the same radius from A

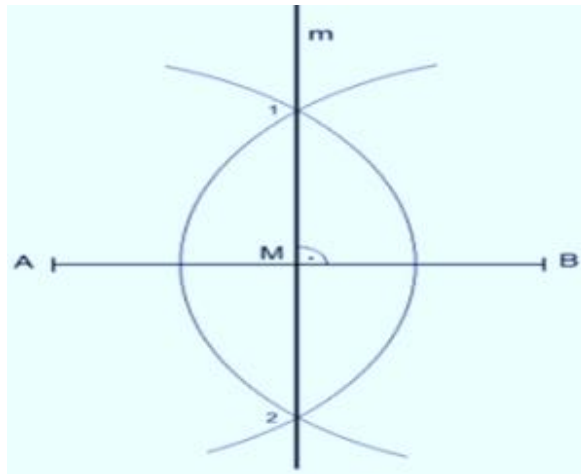
10. Which geometric principle is used to justify the construction below?



- a) A line perpendicular to one of two parallel lines is perpendicular to the other
- b) Two lines are perpendicular if they intersect to form congruent adjacent angles

- c) When two lines are intersected by a transversal and alternate interior angle are congruent, the lines are parallel
- d) When two lines are intersected by a transversal and the corresponding angles are congruent, the lines are parallel

11. The diagram below shows the construction of the perpendicular bisector of AB.



Which statement is not true?

- a)  $AM=MB$
  - b)  $MB=1/2AB$
  - c)  $AM=2AB$
  - d)  $AM+MB=AB$
12. Construct an isosceles triangle given the perimeter and the altitude (perimeter 150mm and altitude 70mm).
13. Construct a rhombus given the diagonal and the length of the sides.
14. Construct a trapezium given the lengths of the parallel sides, the perpendicular distance between them and one angle.
15. Construct a regular octagon given the diameter, i.e. within a given square.

### Oral Assessment

1. Which steps are followed when bisecting a line?

### Practical Assessment

1. Construct an equilateral triangle, given one of the sides,  $AB = 100$ .
2. Construct a triangle given the base, the altitude and the vertical angle (base 100mm and vertical angle  $65^\circ$ )
3. Construct a triangle similar to another triangle but with a different perimeter

### 3.3.3.4 Tools, Equipment, Supplies and Materials

- Drawing room
- Computer lab



- Drawing equipment and materials
- Computers
- CAD package
- Overhead projector

### 3.3.3.5 References



Childs, P. (2003). Mechanical design. Butterworth Heinemann.

Olkun, S. (2003). Making connections: Improving spatial abilities with engineering drawing activities. International journal of mathematics teaching and learning, 3(1), 1-10.


Shrock, C. R. (2009). Advanced AutoCAD 2010 Exercise Workbook. Industrial Press Inc.

Yamaguchi, F. (2012). Curves and surfaces in computer aided geometric design. Springer Science & Business Media.

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### 3.3.4 Learning outcome No 3: Produce Solid Geometry

#### 3.3.4.1 Learning Activities

Learning Outcome No 3: Produce Solid Geometry		
	Learning Activities	Special Instructions
	3.1 Interpret drawings of patterns 3.2 Develop patterns	<ul style="list-style-type: none"><li>• Demonstrations and group discussion</li><li>• Use the correct dimensions</li></ul>

#### 3.3.4.2 Information Sheet No3/LO3: Produce Solid Geometry



##### Introduction

In this outcome, the areas covered are interpretation of sketches and drawings of patterns, surface development of interpenetrating solids and truncated solids, and interpenetration of solids.

##### Definition of key terms

**Straight line:** It is a line such that, if any portion of it is placed with its ends in the line, the entire portion so placed will lie in the line, however it may be applied.

**A plane surface (or plane):** It is a surface of unlimited extent such that whatever two of its points are taken, a straight-line joining them will lie wholly in the surface.

**A plane figure:** It is a geometric figure all of whose points lie in one plane. Plane Geometry treats of plane figure.

##### Content/Procedures/Methods/Illustrations

**Solid geometry:** interpretation of sketches and drawings, surface development of prisms, cylinders, truncated prisms, cones and pyramids. Development of surfaces of interpenetration cylinders and truncated solids, and interpenetration of cylinder to cylinder and cylinder to prism or prism to prism of equal and unequal diameters.

**Design elements**  
**Solid geometry**

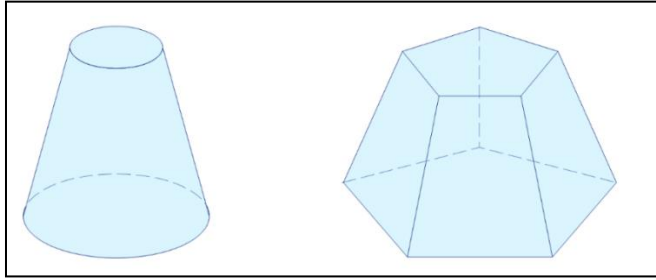


Figure 37: Shapes, Cone and Pentagonal pyramid with flat tops  
Source: [www.conceptdraw.com](http://www.conceptdraw.com)

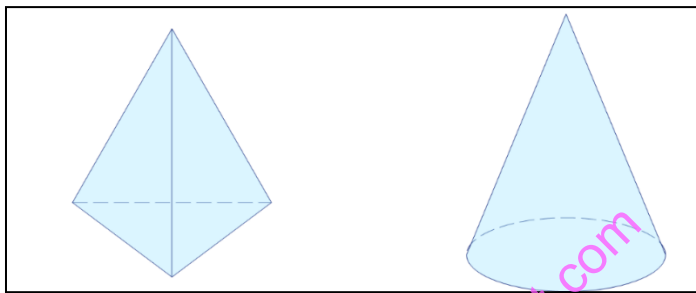


Figure 38: Cone and 4-sided pyramid  
Source: [www.conceptdraw.com](http://www.conceptdraw.com)

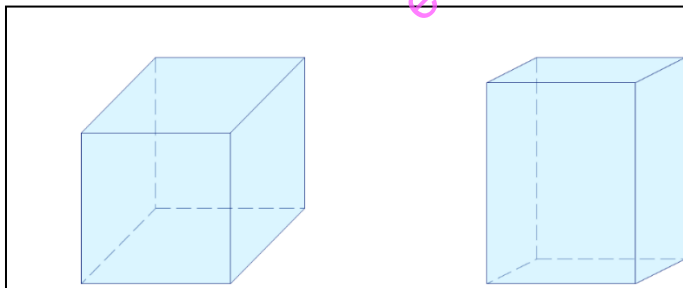


Figure 39: Cube and rectangular Box  
Source: [www.conceptdraw.com](http://www.conceptdraw.com)

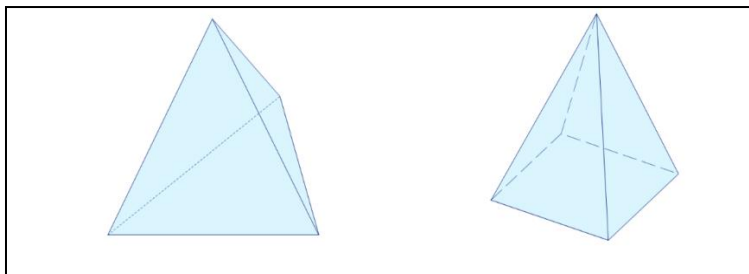


Figure 40: Tetrahedron and Pyramid  
Source: [www.conceptdraw.com](http://www.conceptdraw.com)

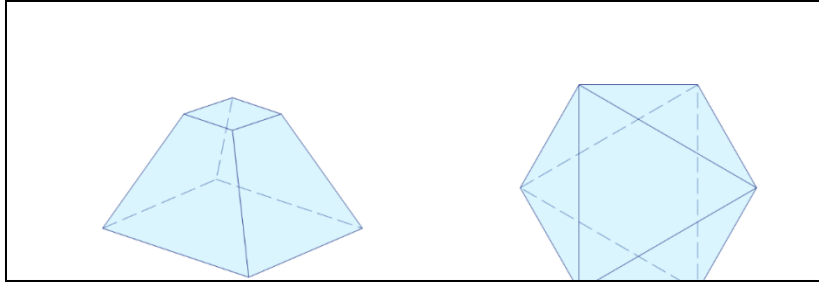


Figure 41: Pyramid with flat top and octahedron

Source: [www.conceptdraw.com](http://www.conceptdraw.com)

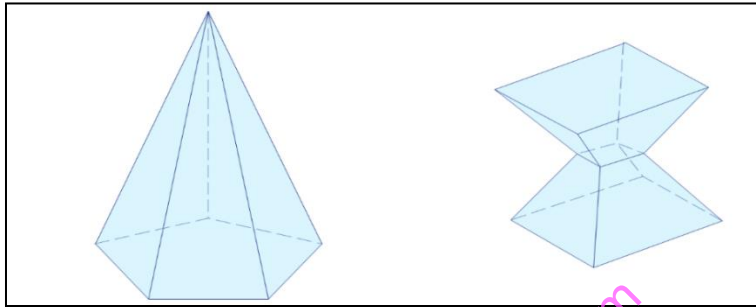


Figure 42: pentagonal Cone and Irregular polyhedron

Source: [www.conceptdraw.com](http://www.conceptdraw.com)

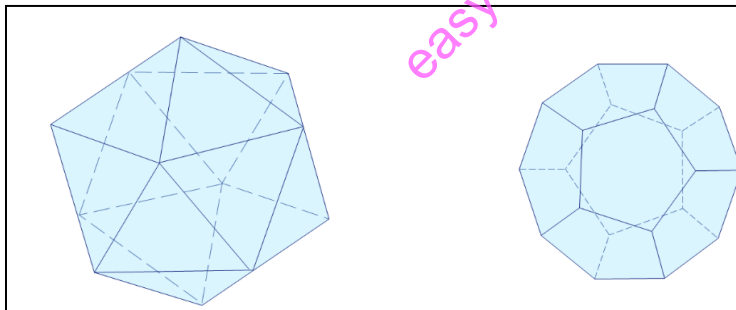


Figure 43: Icosahedron and decahedron

Source: [www.conceptdraw.com](http://www.conceptdraw.com)

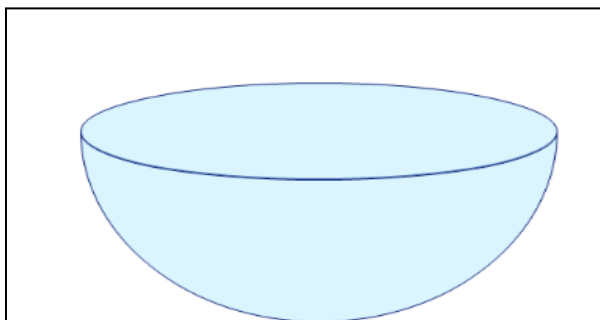


Figure 44: Half Sphere

Source: [www.conceptdraw.com](http://www.conceptdraw.com)

**Use these shapes to draw your geometrical diagrams and illustrations**

1. The sides of the quadrilateral are in the ratio of 2:3:4:5. The triangle BCE is half the area of the quadrilateral.
  - a) Draw the given figures showing clearly how the points C, D and E are obtained.
  - b) Draw a square which shall have the same area as the figure ABCDE.

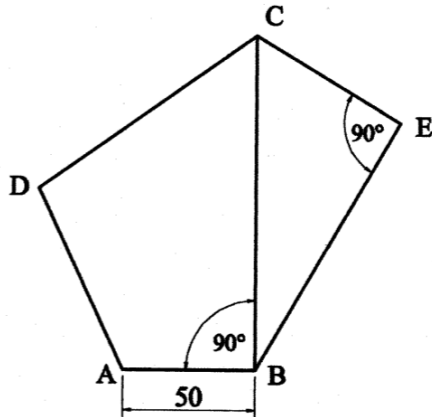


Figure 45: Plan and elevation of a sphere

2. The figure below shows the plan and elevation of a sphere with a point P on its surface. The elevation of a cone which is in contact with the sphere is also shown.
  - a) Draw the plan and elevation of both solids and show the position of the point P in the plan.
  - b) Draw the plan and elevation of another sphere, having a diameter of 40mm, which shall be in contact with the given sphere at point P.

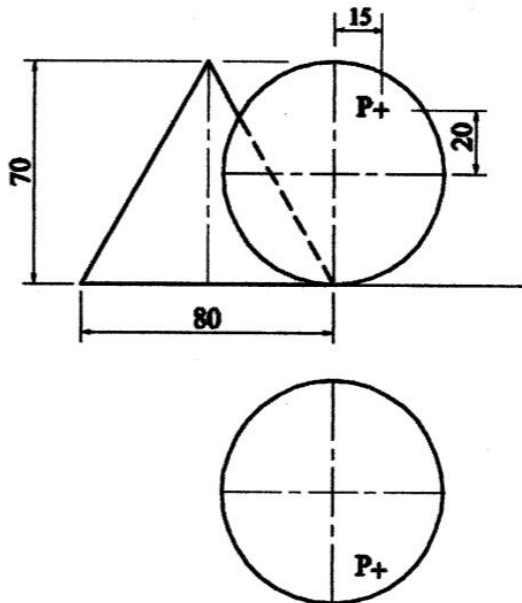


Figure 46: Plan and elevation of another sphere

## Conclusion

This outcome covered interpretation of sketches and drawings, surface development of solids, and interpenetration of surfaces.

## Further Reading



1. Davies, B. L., Robotham, A. J., & Yarwood, A. (1991). Computer-aided drawing and design. London: Chapman & Hall.

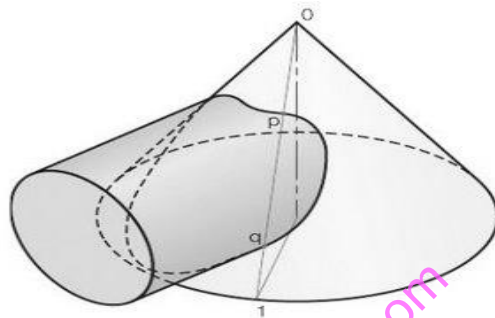
## 3.3.4.3 Self-Assessment



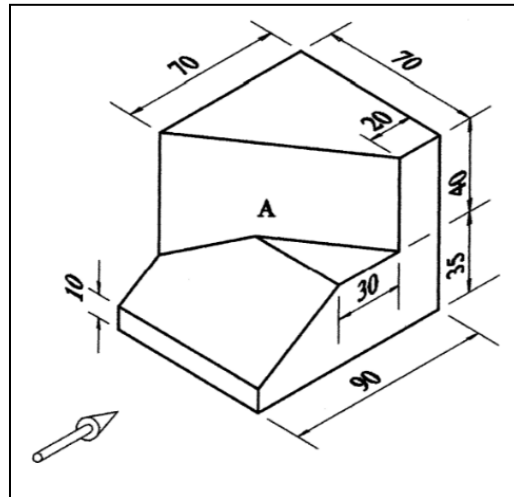
### Written Assessment

1. A cylinder is placed on H.P on its base and section plane is parallel to V.P cutting the solid the section gives \_\_\_\_\_
  - a) parabola
  - b) circle
  - c) rectangle
  - d) ellipse
2. A cylinder is placed on H.P on its base and section plane is parallel to H.P cutting the solid the section gives \_\_\_\_\_
  - a) Parabola
  - b) Circle
  - c) Rectangle
  - d) ellipse
3. A cylinder is placed on H.P on its base and section plane is inclined to V.P and perpendicular to H.P cutting the solid the section gives \_\_\_\_\_
  - a) Parabola
  - b) Circle
  - c) Rectangle
  - d) ellipse
4. If a plane is inclined with both the reference plane then the plane come under \_\_\_\_\_
  - a) auxiliary plane
  - b) oblique plane
  - c) perpendicular plane
  - d) cross planes

5. If a plane is inclined to both the reference planes then the traces would meet at \_\_\_\_\_ line except the plane perpendicular to picture plane.
- XY reference
  - Vertical reference
  - Above the XY reference plane
  - Below the XY reference plane
6. Draw a radial element (0, 1) in one of the orthographic views. Find the points on the line of interpenetration (i.e., p & q) and project them to the other views. Repeat with more radial elements until you have enough points to draw the lines of interpenetration.



7. An isometric view of a shaped solid is shown the figure below.
- Draw an elevation of the solid looking in the direction of the arrow.
  - Project a plan from the elevation.
  - Project a new elevation from the plan of the solid which will show the true shape of the surface



### Oral Assessment

What is solid geometry

### Practical Assessment

Given pyramid is cut by plane,  $\perp$  to the frontal plane and inclined at  $70^\circ$  to the top plane. The cutting plane cuts the axis of the pyramid at 15mm from the apex. Draw the projections of the remaining part of the pyramid and the true shape of the cut section.

#### 3.3.4.4 Tools, Equipment, Supplies and Materials

- Drawing room
- Computer lab
- Drawing equipment and materials
- Computers
- CAD package
- Overhead projector

#### 3.3.4.5 References




- Aouad, G., Wu, S., Lee, A., & Onyenobi, T. (2013). Computer aided design guide for architecture, engineering and construction. Routledge.
- Bergen, S. D., Bolton, S. M., & Fridley, J. L. (2001). Design principles for ecological engineering. *Ecological Engineering*, 18(2), 201-210.
- Liu, S. X., Hu, S. M., Chen, Y. J., & Sun, J. G. (2001). Reconstruction of curved solids from engineering drawings. *Computer-Aided Design*, 33(14), 1059-1072.



### 3.3.5 Learning Outcome No 4: Produce Pictorial and Orthographic Drawings of Components

#### 3.3.5.1 Learning Activities

Learning Outcome No 4: Produce Pictorial and Orthographic Drawings of Components	
 <b>Learning Activities</b>	<b>Special Instructions</b>
4.1 Identify and interpret the meaning of symbols and abbreviations 4.2 Interpret and produce first and third angle orthographic drawings 4.3 Dimension orthographic elevations	

#### 3.3.5.2 Information Sheet No3/LO4: Produce Pictorial and Orthographic Drawings of Components



##### Introduction

This outcome covers meaning of pictorial and orthographic drawings, sectioning, symbols and abbreviations, drawing of isometric, oblique, axonometric, auxiliary and perspective views, drawing of first and third angle projections, sectioning of components, and free hand sketching of tools, equipment, components, geometric forms and diagrams.

##### Definition of key terms

**Axonometric (Pictorial) Projections-** These are drawings in which the object is drawn in three dimensions (3-D) i.e. three sides of the object

##### Content/Procedures/Methods/Illustrations

#### 4.1 Solid geometry principles

All views presented in a solid geometry are assumed to be from the same object, and only the particular object but from different points of view and that all views are at the same scale. All the visible edge is depicted by a line and assumptions are made that those edge progress away from the viewer to form faces that are flat but at right angles. The true angle between a line and a plane is seen in a view showing the line as a true length and the plane as an edge. All horizontal sections of an upright or inverted right cone are circles. A sphere appears as a circle in every view.

A sphere and cone in contact will have a common tangent plane. When two spheres touch one another: the point of contact lies on the line joining the two centers, the distance between their centers is equal to the sum of the radii, and the point of contact can be located in any view, by dividing the line in the ratio of the radii. The vertical trace of a plane is the line in which the plane meets the vertical plane. The horizontal trace of a plane is the line in which the plane meets the horizontal plane.

### **Axonometric (Pictorial) Projections**

These are drawings in which the object is drawn in three dimensions (3-D), i.e. three sides of the object appear in one drawing. Normally only one drawing is prepared/used.

- They are used extensively in artistic drawing.
- A three-dimensional view (i.e. shows length, width and height of the object simultaneously).
- Provides only a general impression of the shape of the object by allowing the observer to see three of its sides as well as its three overall dimensions.
- An exact and complete description of its shape, particularly as applied to its slots on the underside is lacking.

Two standards are currently used for axonometric projections: diametric projection and isometric Projection.

### **Diametric Projection**

In diametric projection, all dimensions along two axes are drawn to TRUE SIZE. The dimensions along the third axis are HALVED. This projection is preferred when one view of the object is to be emphasized than the other two views (i.e. when that one view is of more interest than the other views).

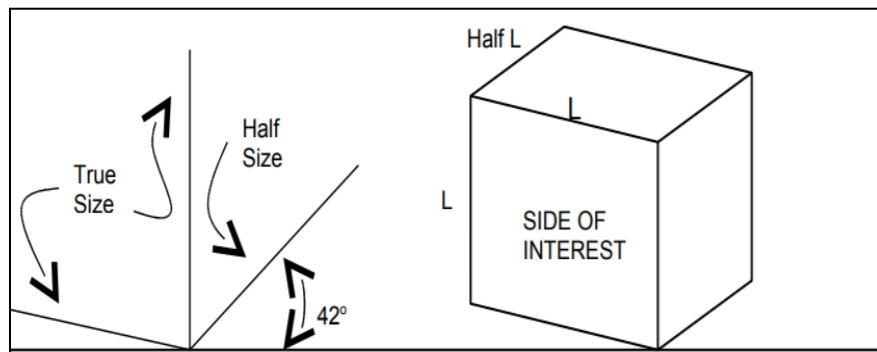


Figure 47: Diametric Projection

## Isometric Projection

In isometric projection, all dimensions along all the three axes are drawn to TRUE SIZE. Isometric projection is preferred when the three views of the object are of equal importance for accurate presentation of the object.

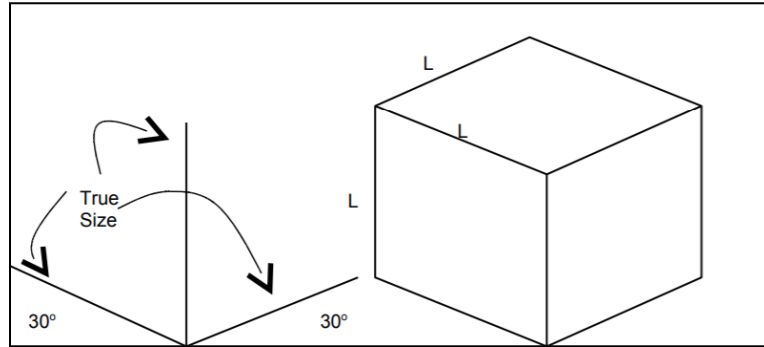


Figure 48: Isometric Projection

## 4.3 Orthographic Projections

To present an object in a unique way, generally more views (and sometimes sections) are required. In orthographic projection, the views are seen in directions that make right angles (i.e.  $90^\circ$ ) with each other. The number of views needed should be sufficient to represent the object completely and conveniently, but it should be kept to the minimum. For most purposes, three views are usually sufficient.

- Engineering (Technical) drawings usually utilize orthographic views (OV) rather than pictorial views.
- Orthographic (OV) help to record the shapes of objects exactly and completely.
- OV is a two-dimensional (2-D) drawing. It shows only one side of an object and two of its overall dimensions.
- A minimum of two OV is required to show the three dimensions of any object and therefore to describe its shape completely. Some features of the object that do not directly appear on viewing the object from any specific direction (known as hidden details) are shown on the drawing as dotted lines.

## Naming of Views

In orthographic projection, three views are normally drawn. The three chosen views may be any of the six hypothetical faces of the object. These views are named as shown below.

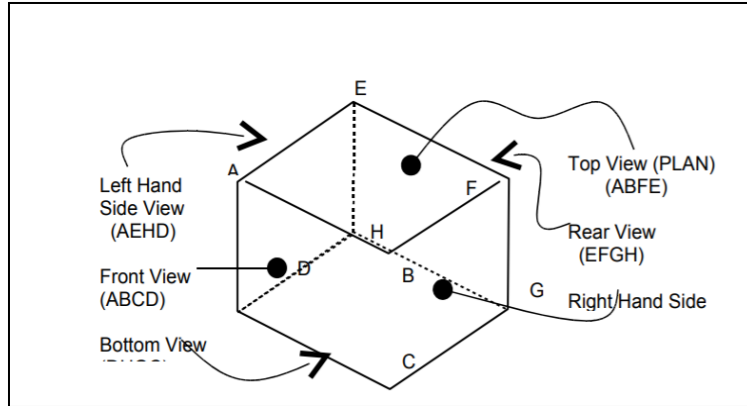


Figure 49: Naming of views

The Front View (ABCD) – abbreviated as FV, is that view of utmost importance in representing the object (normally the most complicated of all the views) as seen when the object is placed directly in front of the viewer. This view generally serves to represent the object (e.g. a work piece) in the most common position in which it is used. It is normally the first view to be drawn – other views following thereafter. The Rear View – RV (EFGH) is directly opposite the FV at the back of the object. The Right-Hand Side View – RHSV (BFGC) and the Left-Hand Side View – LHSV (AEHD) appear on the right and left sides of the object, respectively. The Top (ABFE) and Bottom (DCGH) Views are at the top and bottom sides of the FV. As you must have noted, these six views are at right angles to one another.

#### 4.4 Standard Orthographic Projections

Two standards are commonly in use in orthographic projection of drawings; the First Angle Projection and the Third Angle Projection (American projection). It should be noted that corresponding views are identical in both methods of projection except for their relative positions on the drawing paper.

##### The First Angle Projection

**Symbol:**

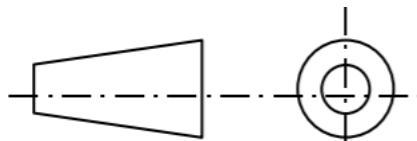


Figure 50: First Angle projection

In here, the front view (A) is the basis (reference) and the other views are drawn as ‘shadows’ of that view. That is, the left-hand side view for instance is drawn on the right side of the front view. Similarly, the top view (plan) is drawn at the bottom of the front view, etc.

**The Third Angle Projection  
Symbol**

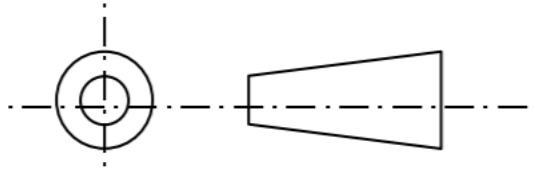
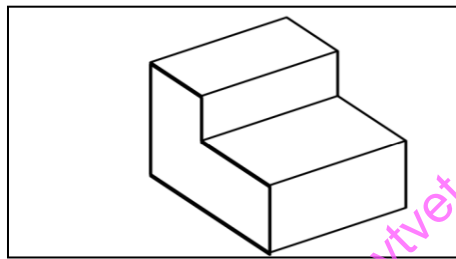


Figure 51: The Third Angle Projection

In here, the front view is the basis (just as before) but the other views are drawn as ‘reflections’ of that view. The left-hand side view is drawn on the left-hand side of the front view. Similarly, the top view (plan) is drawn at the top of the front view.

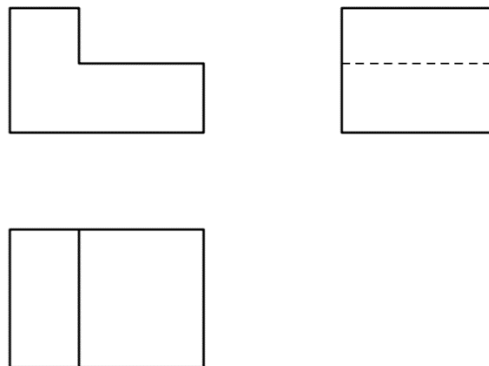
**Example:** The Front View (FV), Left Hand Side View (LHSV) and Top View (PLAN) of the given object



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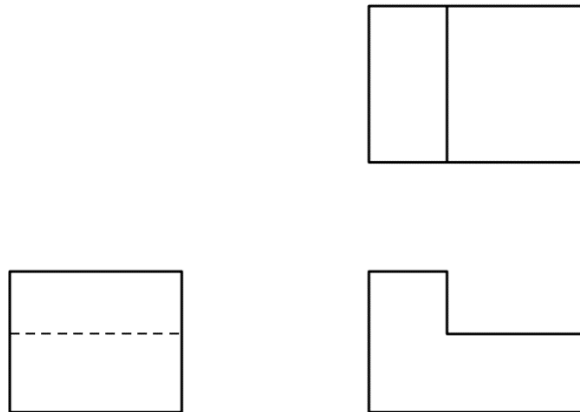
**SOLUTION I**

**First Angle Projection**



**SOLUTION II**

## Third Angle Projection



## Assembly Drawings

As the name indicates, assembly drawings are nothing more but a collection of detail drawings (each of which forms part of that assembly) put together in a logical way. The drawing serves someone who is to assemble the individual parts so as to get a single unit in its working condition.

### Notes

- Only the external extreme dimensions of the assembly are indicated.
- Each component is identified by its part reference number. This number is used in the parts list.
- (Where details of that part are indicated e.g. the drawing number for its detail drawing).
- Sectional views are in most cases preferred as they show in a detailed form how the parts interact in an assembly.
- Only one view is normally drawn, unless where the unit is so complex such that the interaction of all parts cannot be clearly presented in one view.

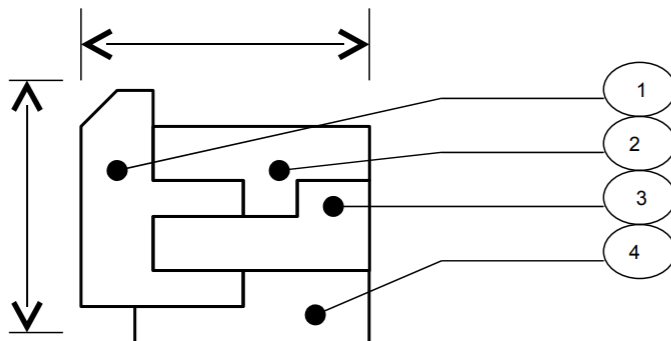


Figure 52: Assembly drawing

If the unit has one or more moving parts, the extreme positions of the moving part are indicated in dotted lines (and the dimensions). This allows for consideration on space limitation during installation

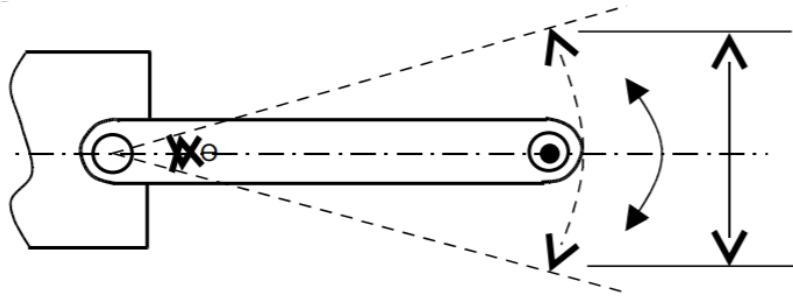
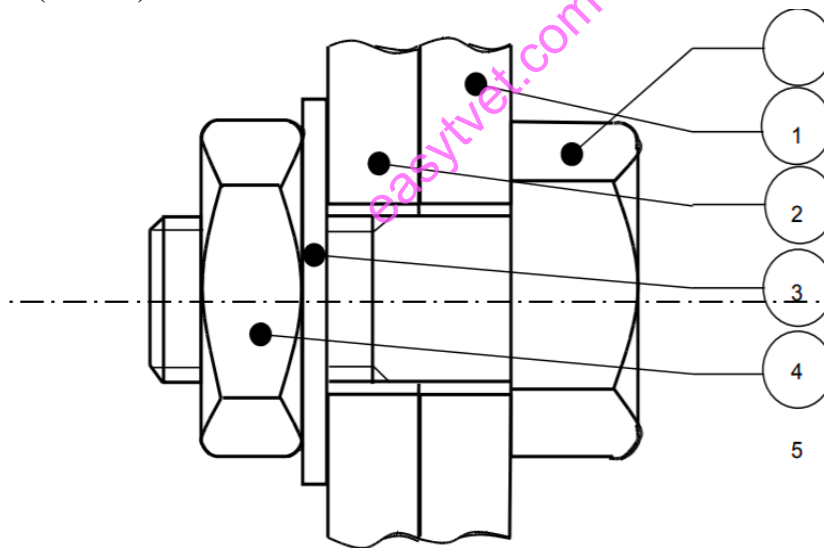


Figure 53: Assembly drawing without detail Specifications

Detail specifications of the individual parts are never shown on an assembly drawing (as they already appear on the respective detail drawing of the respective part)

**Exercise to summarize**

1. Draw an assembly of two stainless steel plates (SS 306) held together by a bolt and a nut (SS 318).



REF. NUMBER	NAME OF PART	NO. REQ'D	MATERIAL	STANDARD/DIMENSION	DRW. NUMBER
5	Nut	1	SS 318	M10	005
4	Washer	1	SS 318	M10	004
3	Plate # 2	1	SS 306	-	003
2	Plate # 1	1	SS 306	-	002
1	Bolt	1	SS 318	M10	001

Figure 54: Stainless steel plates

**NOTE:** Materials SS 306 and SS 318 are different

2. Draw the orthographic projections of the following points.
- a) Point P is 30 mm above HP and 40 mm in front of VP
  - b) Point Q is 25 mm above HP and 35 mm behind VP
  - c) Point R is 32 mm below HP and 45 mm behind VP
  - d) Point S is 35 mm below HP and 42 mm in front of VP
  - e) Point T is in HP and 30 mm. is behind VP
  - f) Point U is in VP and 40 mm below HP
  - g) Point V is in VP and 35 mm above HP
  - h) Point W is in HP and 48 mm in front of VP

### Projection of Lines

The shortest distance between two points is called a straight line. The projectors of a straight line are drawn therefore by joining the projections of its end points. The possible projections of straight lines with respect to V.P and H.P in the first quadrant are as follows:

- i. Perpendicular to one plane and parallel to the other.
- ii. Parallel to both the planes.
- iii. Parallel to one plane and inclined to the other.
- iv. Inclined to both the planes.

### Conclusion

This outcome covered orthographic views, pictorial drawing, oblique drawings, sectioning, axonometric, auxiliary first, and third angle projections, and free hand sketching.

### Further Reading



- 1. Geometric and Engineering drawing Third Edition K Morling.
- 2. Engineering Drawing with CAD Applications by O. OSTROWSKY

### 3.3.5.3 Self-Assessment

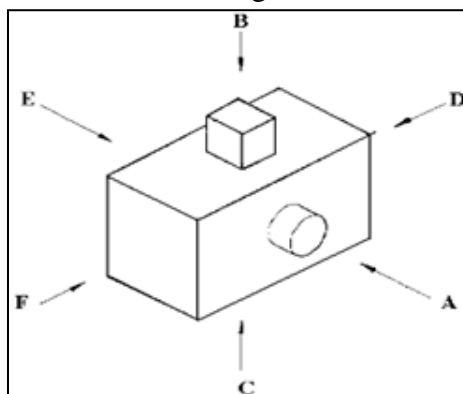


### Written Assessment

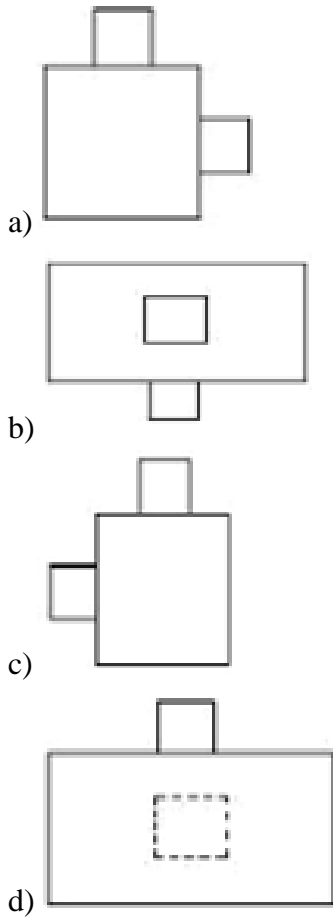
1. Orthographic projection is drawn using two methods which is \_\_\_\_\_
- a) Second angle and third angle method
  - b) First angle and third angle method



- c) First angle and fourth angle method
  - d) Second angle and fourth angle method
2. The method in which the object is placed in the first quadrant is known as \_\_\_\_ method.
- a) Third angle
  - b) Second angle
  - c) First angle
  - d) Fourth angle
3. In first angle method the top view is drawn \_\_\_\_\_ of the front view.
- a) Above
  - b) Right Side
  - c) Left side
  - d) Bottom
4. The method in which the object is placed in the third quadrant is known as \_\_\_\_\_ method.
- a) Third angle
  - b) Second angle
  - c) First angle
  - d) Fourth angle
5. In third angle method the top view is drawn \_\_\_\_\_ of the front view.
- a) Above
  - b) Right Side
  - c) Left Side
  - d) Bottom
6. Question that fall is for the diagram drawn below:



7. Taking 'A' as the FRONT VIEW. Which view will letter 'D' represent?



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**Oral assessment**

What is the difference between orthographic projection and isometric drawing?

**Practical Assessment**

Draw the orthographic of vehicle engine

**3.3.5.4 Tools, Equipment, Supplies and Materials**

- Drawing room
- Computer lab
- Drawing equipment and materials
- Computers
- CAD package
- Overhead projector

### 3.3.5.5 References



Morling, K. (2010). Geometric and engineering drawing. Routledge.


Shrock, C. R. (2004). Exercise workbook for beginning AutoCAD 2005. Industrial Press Inc.

Yamaguchi, F. (2012). Curves and surfaces in computer aided geometric design. Springer Science & Business Media.

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### 3.3.6 Learning Outcome No 5: Apply CAD Packages in Drawings

#### 3.3.6.1 Learning Activities

Learning Outcome No 6: Apply CAD Packages in Drawings		
	Learning Activities	Special Instructions
	5.1 Select CAD packages 5.2 Apply CAD packages in production of electrical drawings	<ul style="list-style-type: none"> <li>Provide all the information of the object to be drawn i.e.</li> </ul>

#### 3.3.6.2 Information Sheet No3/LO6: Apply CAD Packages in Drawings



##### Introduction

This outcome covers use of CAD applications to draw pictorial and orthographic drawings and sectioning, symbols and abbreviations, 2D and 3D drafting technique and apply CAD packages in production of electrical drawings.

##### Definition of key terms

**CAD (Computer Aided Design):** It is the use of computer software to design and document a product's design process.

**Engineering drawing:** The use of graphical symbols such as points, lines, curves, planes and shapes.

##### Content/Procedures/Methods/Illustrations

CAD (Computer Aided Design) is the use of computer software to design and document a product's design process. To many engineering problems, a solution requires a combination of organization, analysis, problem solving principles and a graphical representation of the problem. Objects in engineering are represented by a technical drawing/drafting that represents designs and specifications of the physical object and data relationships. Since a technical drawing is precise and communicates all information of the object clearly by use of Computer Aided Design. CAD is used to design, develop and optimize products. CAD is used in the design of tools and equipment required in the manufacturing process as well as in the construction domain.

## How CAD software system works

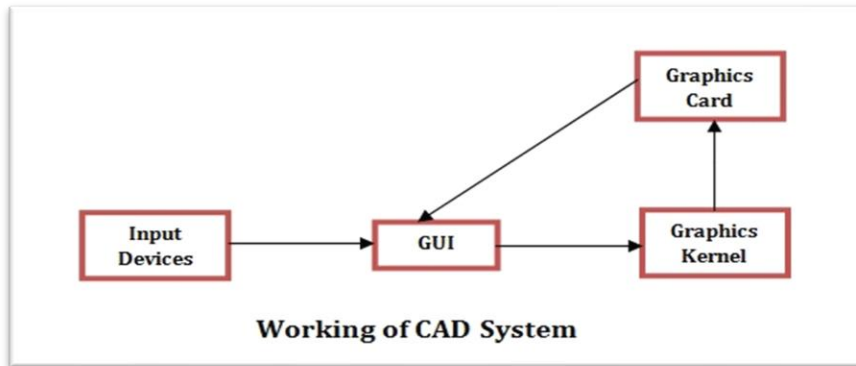


Figure 55: Working of a CAD system

## CAD software enables

- Efficiency in the quality of design
- Increase in the Engineer's productivity
- Improve record keeping through better documentation and communication

## Types of CAD Software

- 2D CAD
- 3D CAD
- 3D Wireframe and Surface Modelling
- Solid Modelling

2D CAD	•Flat drawings of products and structures
2.5D CAD	•Prismatic Models
3D CAD	•Realistic model of design object
3D Wireframe and Surface Modeling	•A skeleton-like inner structure of the object being modeled
Solid Modeling	•The program calculates the dimensions of the object it is creating

Figure 56: Types of CAD software

## **2-Dimensional CAD (2D CAD)**

2D CAD is the pioneer of CAD software, developed in the early 70s. It relies on basic geometric shapes like lines, rectangles, circles, etc. to produce flat drawings. Autodesk is one of the pioneering companies that has played a significant role in developing CAD software.

## **3-Dimensional CAD (3D CAD)**

It is a step up from the 2D CAD software. It allows creation of 3D images that are realistic. These images are called 3D models as they can be viewed and rotated in any direction – X, Y or Z.

### **Classification of CAD software in terms of their operating parameters**

- a) **Single-file-mode systems:** This type of CAD software that allows only a single user to work on a single file at a time.
- b) **Referenced file-mode systems:** This type of software, users work on their own files with the files of other users attached as a background. This enables users to leverage other users' work as background data.
- c) **Collaborative-mode systems:** These CAD systems take the referenced-mode system to the next level. They allow a team of users to collaboratively work with each other's data and see the changes other users make to the data as they go. The giants in this field e.g. AutoCAD is used in different modes of an operation.
- d) **Wire-frame models:** They create skeleton like models with lines and arcs. Since they appear to be made of wires, and everything in the background is visible, they are called wire-frame models.
- e) **Surface models:** These models are created by joining 3D surfaces. The surface models are quite realistic.
- f) **Solid models:** They are the most useful CAD models. They also have additional properties like weight, volume and density, just like actual physical objects. These models are commonly used as prototypes to study engineering designs.
- g) **Nano CAD:** It is a professional grade CAD tool that is used by thousands of engineers and designers around the world. Nano CAD plus comes with some additional features. Both of the versions are available at a low-cost annual subscription including timely updates and priority online support.

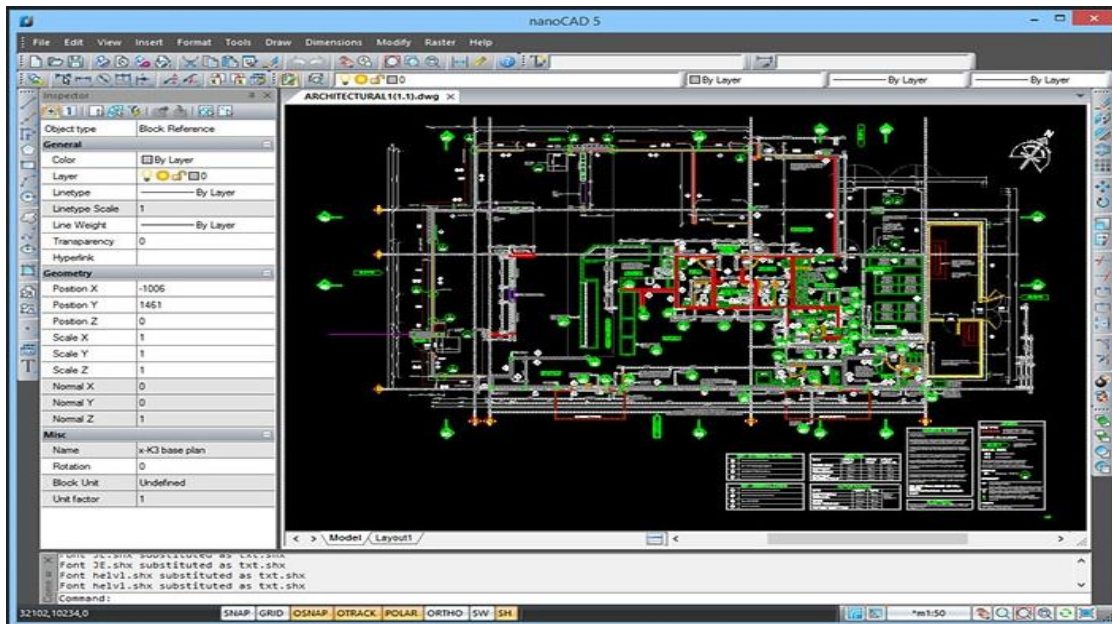


Figure 57: Nano CAD

Source: [www.actcad.com](http://www.actcad.com)

## Features

- Nano CAD and Nano CAD versions are designed For Microsoft Windows (Vista 7, 8, and 10).
- Nano CAD software provides great user experience as it is a multipurpose free drafting software.
- The classic-style CAD user interface offers a command set and UI elements that are familiar and comfortable to users of many other compatible applications of CAD.
- Nano CAD software natively uses the industry-standard DWG (\*.dwg) file format.
- It has a powerful Excel-style table editor having an extensive set of capabilities.
- ActiveX Automation and LISP to automate everyday routine tasks.
- C++/C# API and several other types of API to build CAD applications.

## User interface and various tool bars and commands

CAD has a very versatile user interface that allows you to control the program in several different ways. At the top of the window is a row of menus. Clicking on the Home, Insert, or Annotate causes another selection of menus to appear. This new selection of commands is frequently called a Ribbon or a Dashboard. You can operate the program by clicking on the icons in these menus.

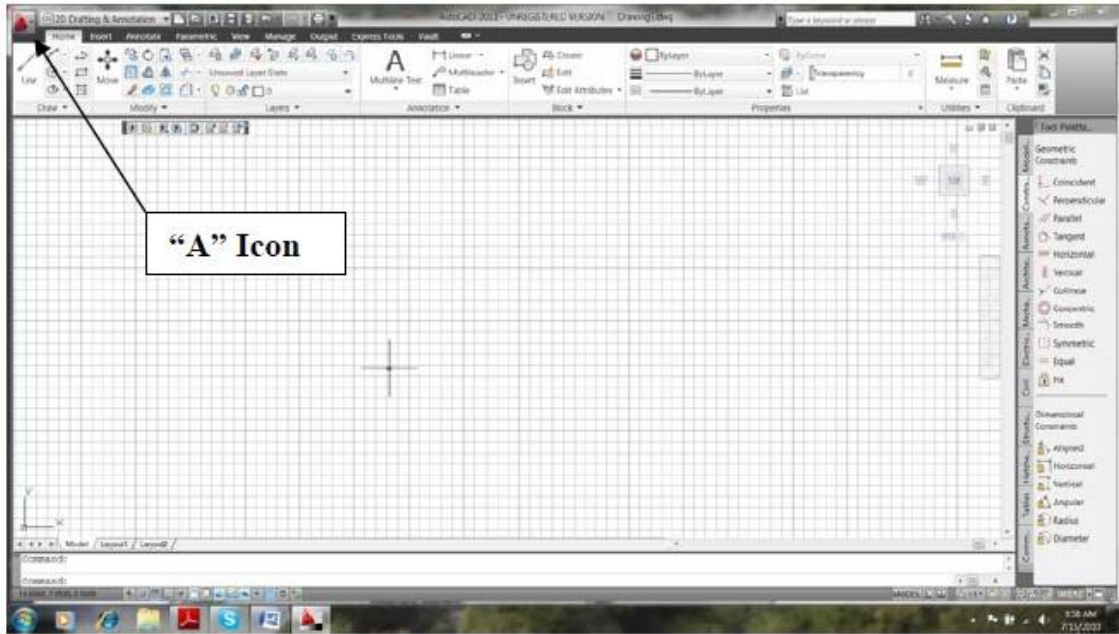


Figure 58: 2D user interface  
 Source: www.actcad.com

**Application of CAD in engineering (2D and 3D)**

Set the CAD parameters as per the drawing's requirements.

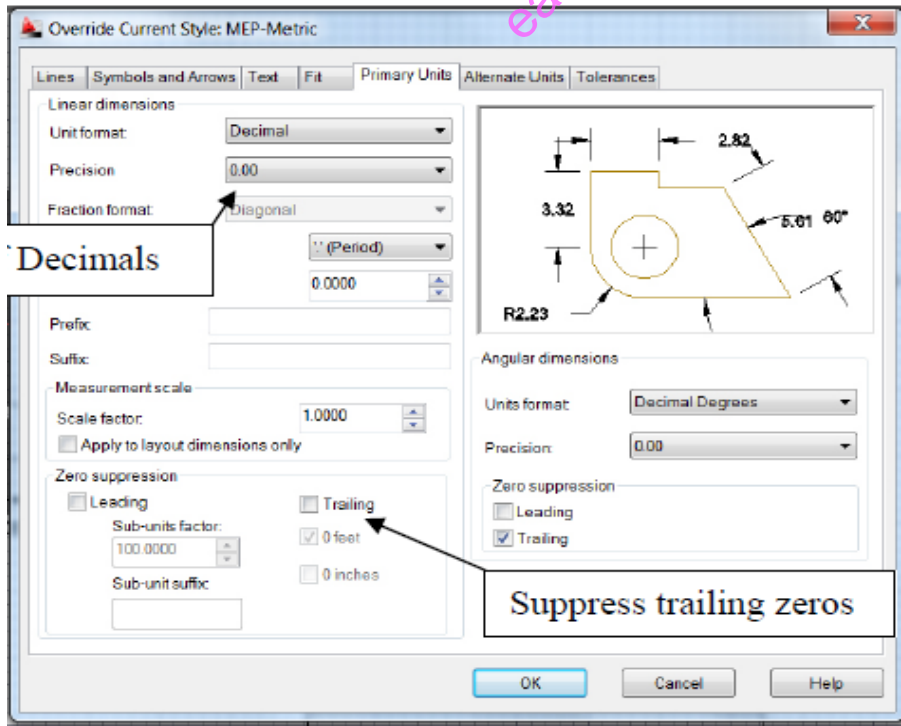


Figure 59: Setting CAD parameters  
 Source: www.actcad.com



Apply different commands to produce engineering drawings.

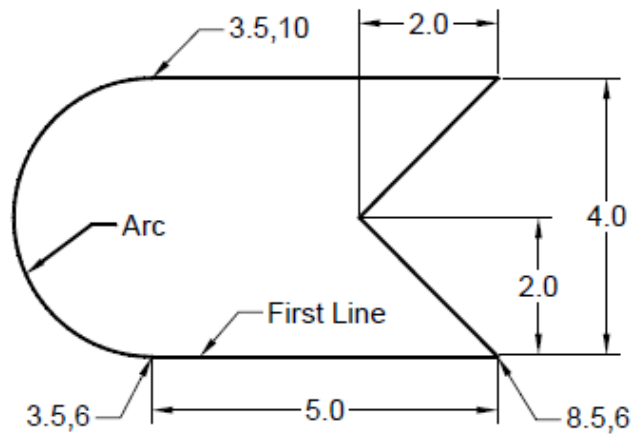


Figure 60: 2D CAD illustration  
Source: [www.archdaily.com](http://www.archdaily.com)

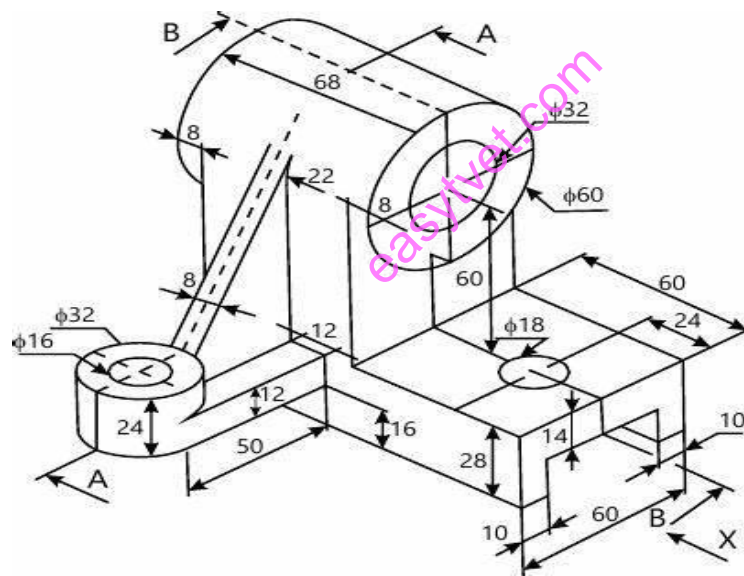


Figure 61: 3D CAD illustration  
Source: [www.archdaily.com](http://www.archdaily.com)

### Electrical drawings

Electrical drawings are technical documents that depict and notate designs for electrical systems. Workers use these documents to install systems on-site. Every type of component and connection has its own specialized symbol and every detail matter in electrical drawings.

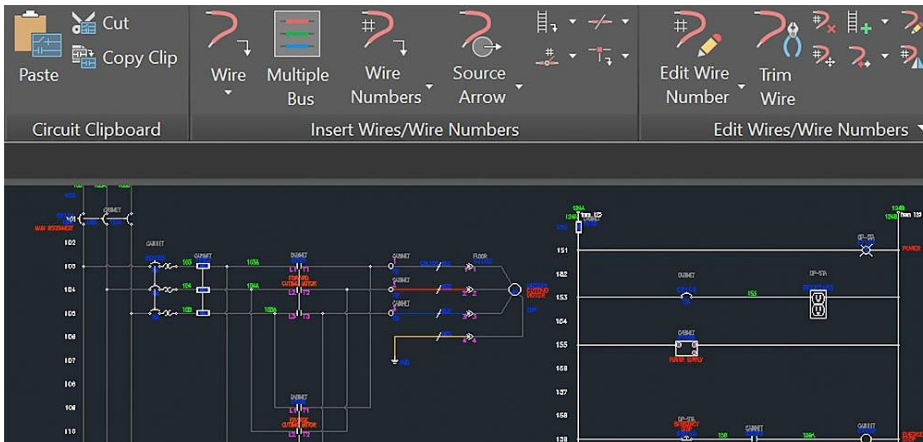


Figure 62: Electrical drawing

Source: [www.electrical-engineering-portal.com](http://www.electrical-engineering-portal.com)

CAD enables these engineers to create electrical and electronic diagrams, control circuit diagrams, schematics and documentation. CAD certainly improves the productivity of electrical engineers as they are able to build default circuits and reuse them later. CAD comes with libraries of parts and symbols which allow electrical engineers to automate design tasks and generate bills of materials (BOM) reports. It's possible to create electrical schematic designs based on wire material type, temperature and maximum voltage drop.

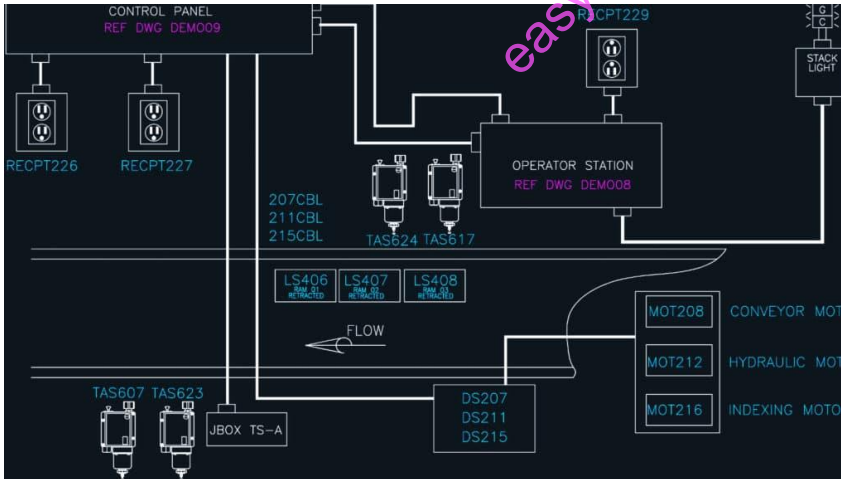


Figure 63: Electrical engineer design

Source: [www.electrical-engineering-portal.com](http://www.electrical-engineering-portal.com)

## How to read electrical drawings

### Symbols used to notate components in an electrical drawing

#### Lights

Use AutoCAD tools to diagram lighting sources

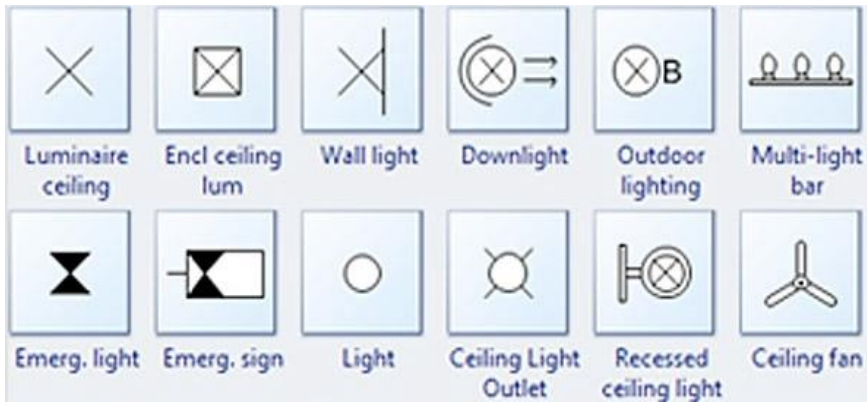


Figure 64: Lights symbol

Source: [www.electrical-engineering-portal.com](http://www.electrical-engineering-portal.com)

#### Switches

From single-pole to multiple-pole, AutoCAD can help you diagram electrical circuits.

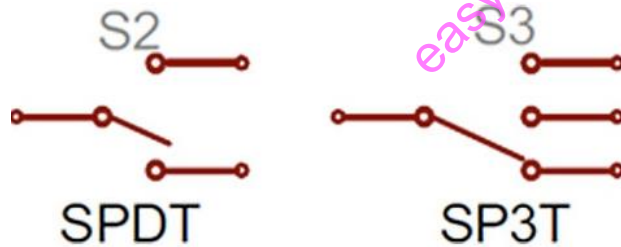


Figure 65: Switch symbol

Source: [www.electronicshub.org](http://www.electronicshub.org)

#### Fuses

Fuses limit the flow of current to prevent damage to other components. With AutoCAD, fuses are easier to design and diagram.



Figure 66: Fuse symbol

## Ground

Electrical circuits must connect to the ground to maintain safety. the correct ways to diagram electrical grounds with AutoCAD

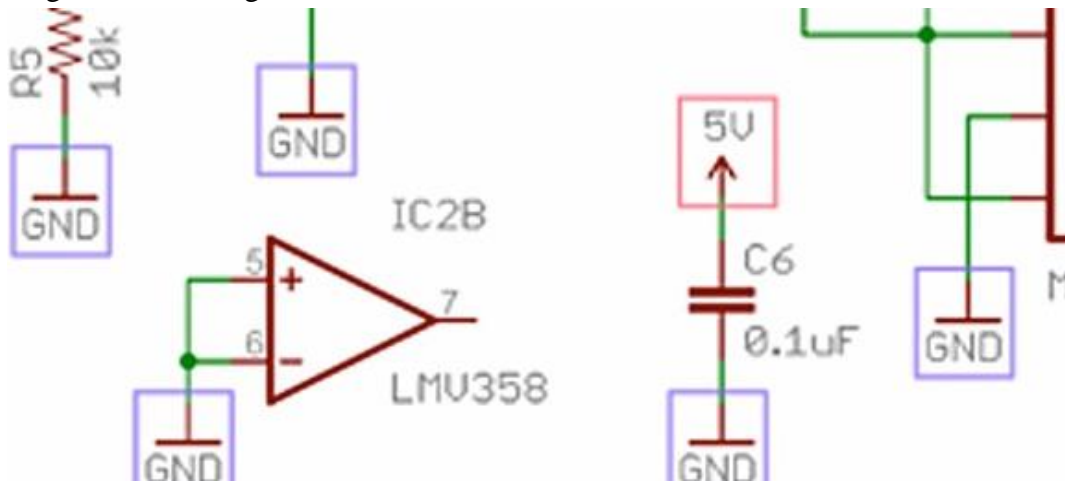


Figure 67: Ground symbol

Source: [www.electronicshub.org](http://www.electronicshub.org)

## WIRES

Wires connect components, and AutoCAD gives you the design power to specify what you need.

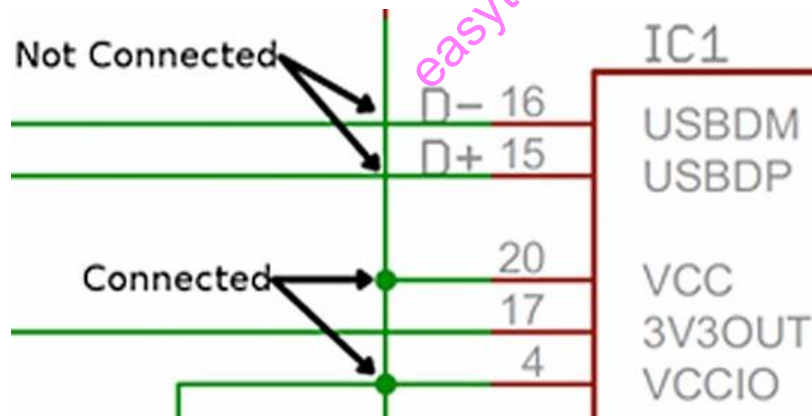


Figure 68: Wires symbol

Source: [www.electronicshub.org](http://www.electronicshub.org)

### Resistors

AutoCAD gives you the design tools to diagram resistors, which reduce current flow, adjust signal levels, divide voltages, and more.

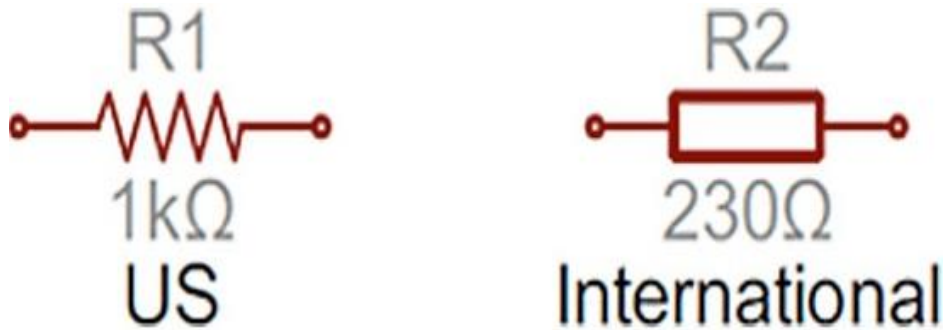


Figure 69: Resistor symbols  
Source: [www.electronicshub.org](http://www.electronicshub.org)

### Capacitors

Capacitors store potential energy; they're polarized or non-polarized. The AutoCAD Electrical toolset enables you to diagram capacitors correctly.

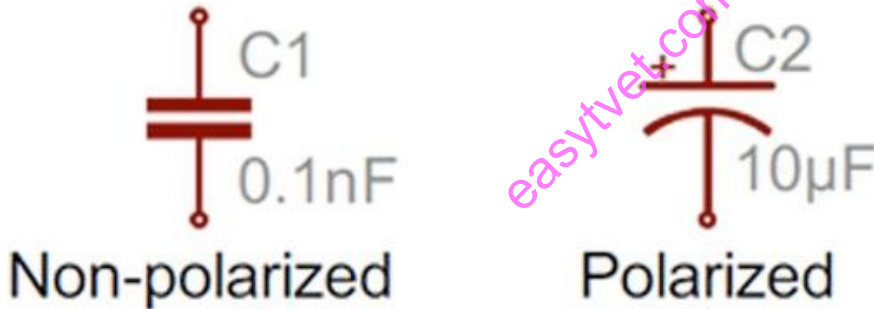


Figure 70: Capacitor  
Source: [www.electronicshub.org](http://www.electronicshub.org)

### Power sources

AutoCAD makes the planning and design from DC to AC currents and batteries process easy.

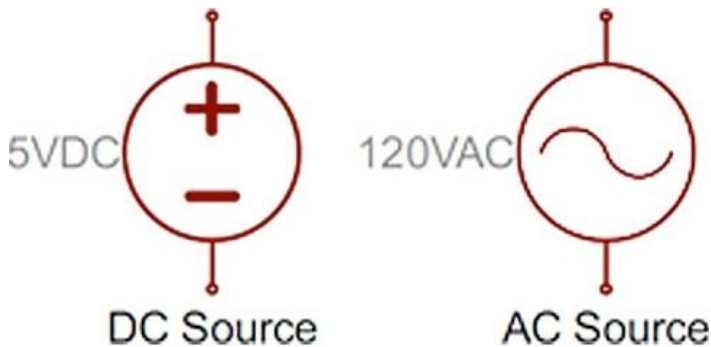


Figure 71: Power sources symbols  
Source: [www.electronicshub.org](http://www.electronicshub.org)

## Mechanical Engineering

Mechanical engineers are concerned with the improvement and modification of mechanical components and systems. They research, design, develop and test mechanical devices. They also research designs and make recommendations based on industry standards and regulations. CAD comes in handy as engineers can design components and assemblies to fit their strict technical specifications. Some CAD programs can also automatically generate a bill of materials (BOM) for a particular design, based on a library of components. Mechanical engineers also make use of simulation to test everything from stress to measuring vibrations in order get the perfect output without having to create and modify real-world prototypes.

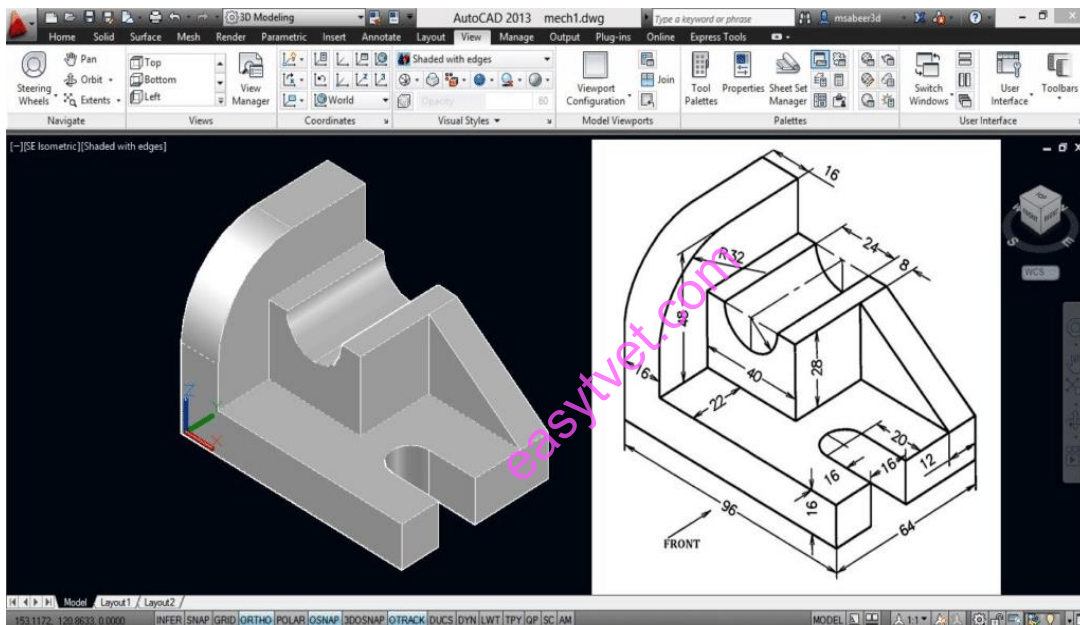


Figure 72: CAD mechanical design

Source: [www.cadpro.com](http://www.cadpro.com)

## Advantages of CAD

- Designs can be altered without erasing and redrawing.
- It offers "zoom" features analogous to a camera lens, whereby a designer can magnify certain elements of a model to facilitate inspection.
- Computer models are three dimensional and can be rotated on any axis, much as one could rotate an actual three-dimensional model in one's hand, enabling the designer to gain a fuller sense of the object.
- Lend themselves to modelling cutaway drawings, in which the internal shape of a part is revealed, and to illustrating the spatial relationships among a system of parts.

### Disadvantages of CAD

- Have no means of comprehending real-world concepts, such as the nature of the object being designed or the function that object will serve.
- Function by their capacity to codify geometrical concepts thus the design process using CAD involves transferring a designer's idea into a formal geometrical model.

### Benefits of CAD to the Engineering Industry

- More precision and control
- Faster design execution
- Cost efficiency
- Better documentation and collaboration

### Conclusion

The learning outcome covered types of CAD and 2D and 3D drafting technique.

### Further Reading



1. <https://www.scan2cad.com/cad/how-engineers-use-cad/>

### 3.3.6.3 Self-Assessment



#### Written Assessment

1. The computer-aided design (CAD) hardware doesn't include \_\_\_\_\_
  - a) Graphic display terminals
  - b) Computer
  - c) Computer programs
  - d) Keyboard
2. How many types of CAD are there?
  - a) 6
  - b) 4
  - c) 2
  - d) 5
3. Modern CAD systems are based on \_\_\_\_\_
  - a) ICG
  - b) GCI
  - c) GIF
  - d) IFG

4. The computer communicates with the user via \_\_\_\_\_
  - a) CPU
  - b) CRT
  - c) Graphics
  - d) Display button
5. The process of designing consists of \_\_\_\_\_ identifiable steps.
  - a) 8
  - b) 5
  - c) 4
  - d) 6
6. The functionality areas of CAD application can be grouped into \_\_\_\_\_ categories.
  - a) 2
  - b) 3
  - c) 4
  - d) 5
7. The colour on CRT screen is obtained by the combination of \_\_\_\_\_
  - a) Red, yellow, blue
  - b) Red, green, blue
  - c) Green, black, yellow
  - d) Red, black, yellow
8. The input devices in CAD can be divided into \_\_\_\_\_
  - a) 2
  - b) 5
  - c) 3
  - d) 4
9. An orthographic projection map is a map projection of \_\_\_\_\_
  - a) Sphere
  - b) Earth
  - c) Cartography
  - d) Top view

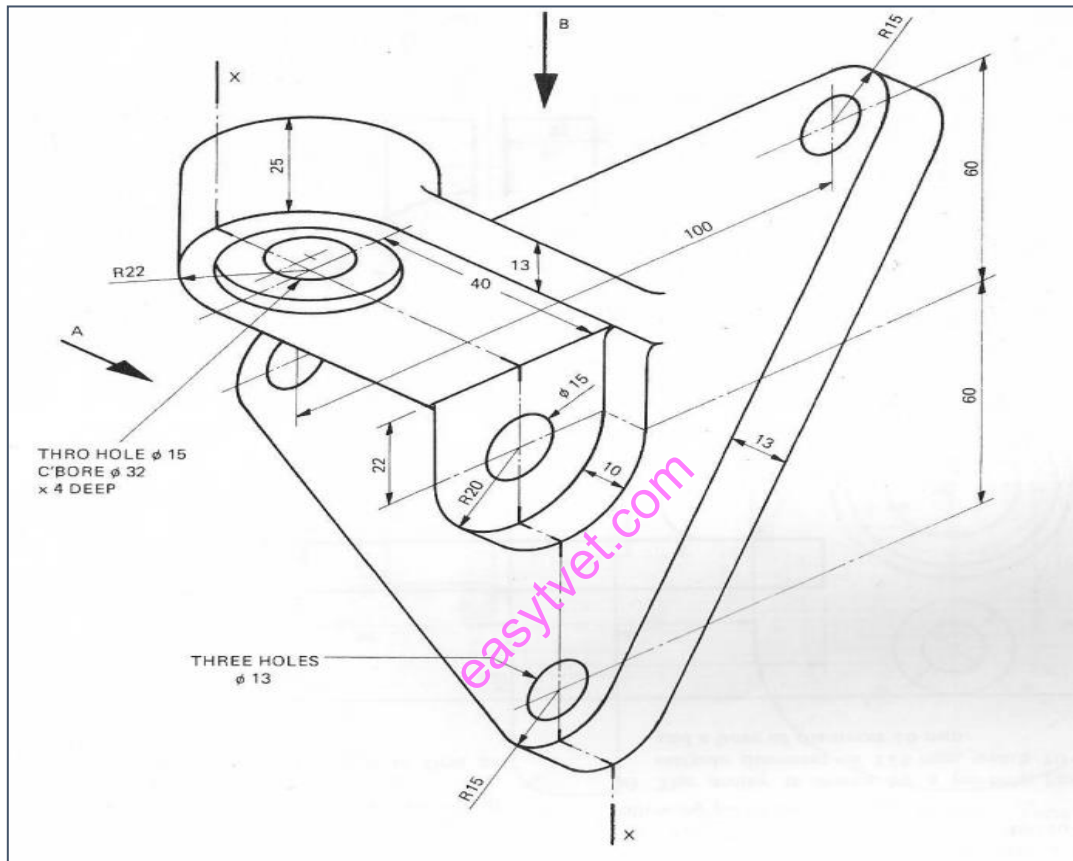
### **Oral Assessment**

1. What are the benefits of CAD?
2. What are the uses of CAD in mechanical engineering?



### Practical Assessment

1. Use CAD application to draw the following views of the figure below in first angle projection.
  - a) Front elevation looking from the direction arrow A
  - b) End elevation looking from the direction arrow B



#### 3.3.6.4 Tools, Equipment, Supplies and Materials

- Drawing room
- Computer lab
- Drawing equipment and materials
- Computers
- CAD package
- Overhead projector

### 3.3.6.5 References



Hubka, V. (2015). Principles of engineering design. Elsevier.

Morling, K. (2012). Geometric and Engineering Drawing. Routledge, amazon

easytvvet.com