CHAPTER 3: DRAINAGE SYSTEMS

Unit of learning code: CON/CU/PL/CR/03/5/A

RELATED UNIT OF COMPETENCY IN OCCUPATIONAL STANDARD: INSTALL DRAINAGE SYSTEMS

3.1 Introduction to the unit of learning

This unit specifies the competencies required to install drainage systems. It involves preparing working drawings, quantifying and cost drainage materials, using drainage tools and equipment setting out drainage systems, install above ground drainage system identifying drainage materials and installing below ground drainage system and testing. It applies in the construction industry.

3.2 Summary of Learning Outcomes

1. Prepare working drawings
2. Quantify drainage materials
3. Use drainage tools and equipment
4. Setting out drainage systems
5. Install above ground drainage system
6. Install below ground drainage system

3.2.1 Learning Outcome 1: Prepare working drawings

3.2.1.1 Introduction to the learning outcome

This learning outcome specifies the competences required by the trainee to prepare working drawings to install drainage system as it involves in the construction industry.

3.2.1.2 Performance Standard

1. Drawings are identified and selected based on the job.
2. Scale of the drawing is determined based on the specifications.

3. Measurements are converted based on scale.
4. Symbols are identified based on standard practices.
5. Isometric pipework drawings are sketched based on drawings.
6. Simple working drawings are produced based on specifications.

3.2.1.3 Information Sheet

The subject of working drawings is one to which a draughtsman cannot give too much attention, for accurate plans and details are absolute essentials for the production of good building. It is well to bear in mind that working drawings are working drawings and not pictures. They should merely aim at being accurate diagrams setting forth exactly the work which is required to be done, with such dimensions as are necessary clearly figured on the drawings, and the conventional colours employed to indicate materials whenever they will aid in expressing the architects intention.

Definitions of terms

- ***Working drawings*** - A comprehensive set of drawings used in a building construction project. They include architectural, structural and other engineering drawings.
- ***Symbol*** is a simplified image of component or things they represent.
- **A plan** a view from above showing the arrangement of spaces in building in the same way as a map, but showing the arrangement at a particular level of a building
- *An elevation* is a view of a building seen from one side, a flat representation of one front of a building
- ***Cross section**,* also simply called a section, represents a vertical plane cut through the object, in the same way as a floor plan is a horizontal section viewed from the top
- **Detail drawings** show a small part of the construction at a larger scale, to show how the component parts fit together.

- **Specification** is a precise description of the materials and methods of workmanship to be employed while carrying out the contract work
- **Schedules** give tables of information on ranges of similar items
- **Bill of Quantities** is a measure or price of the amount of materials and labor and other items required for the building work.
- **Drafting/Draughting;** This the ability to compose drawings that communicate how an object functions or is constructed.
- **Draughtsman**
- This is the person who interprets and draws to scale the engineer's design
- **Cross section**-Is a view seen by cutting an object at right angle to the plan on which it stands.

Introduction to Working

At the design stage, sketch drawings and preliminary drawings will be used to show the designer's intentions. Sketch drawings are also often used by site supervisors and craftsmen to show other operatives how a particular problem might be resolved or how a component can be fabricated on site. Once the design is accepted, production of the working drawings can be done.

The following drawings are used in a range of fields namely;

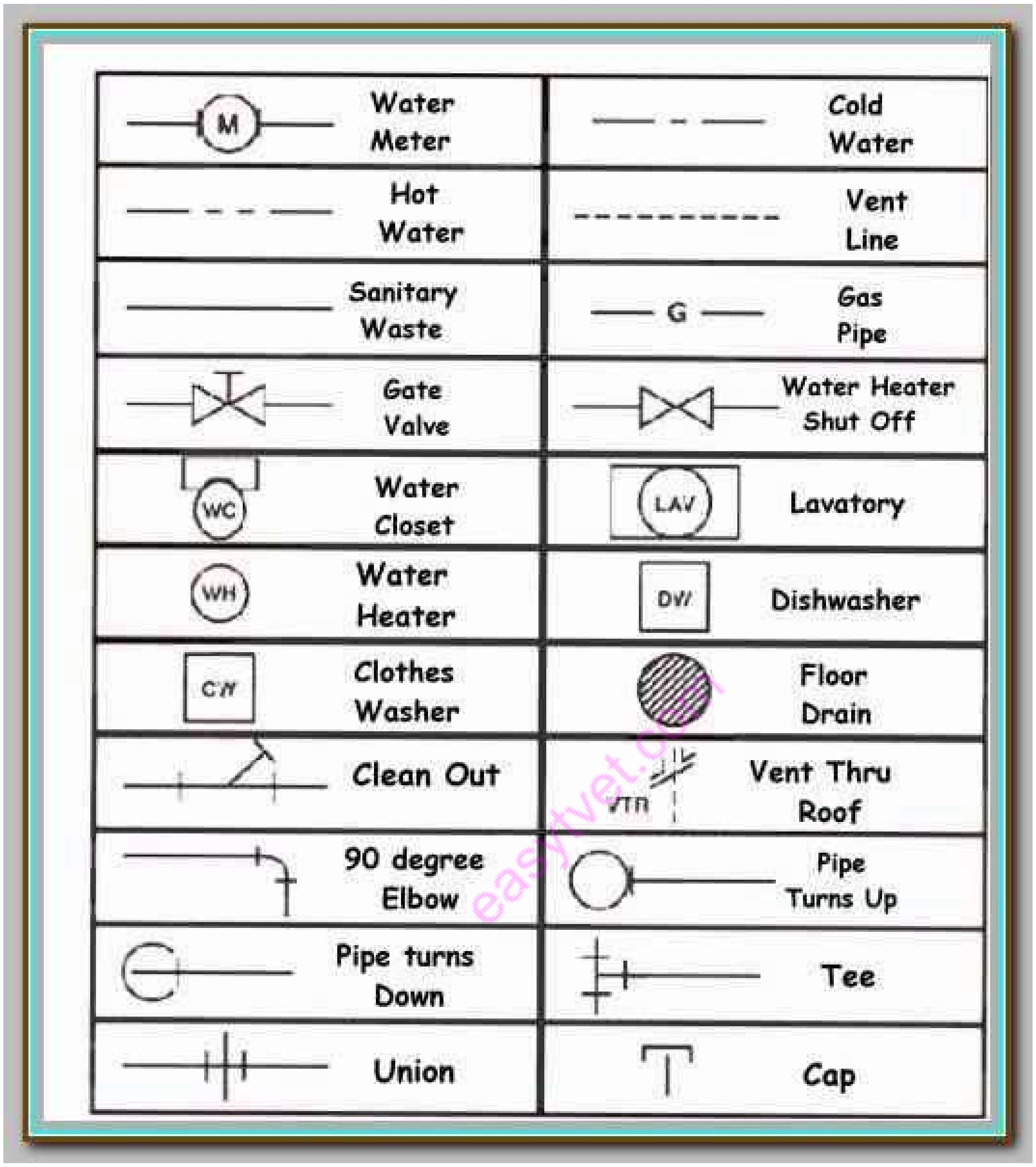
- Mechanical drawings - show information about heating, ventilating, air conditioning and plumbing details in a building.
- A structural drawing includes a plan or set of plans and details for how a building or other structure will be built. They are generally prepared by registered professional engineers, and based on information provided by architectural drawings.
- Architectural drawings are an illustration of what the final product will look like plus an instructional tool on how to achieve it. Architectural drawings can be devoted to depicting an overview of the building i.e., an elevation or they can focus on a particular detail.

A plumbing drawing is a type of technical drawing that provides visual representation and information relating to a plumbing system. It is used to convey the engineering design to plumbers or other workers who will use them to help install the plumbing system.

A **plumbing drawing** is used to show clearly the location of fixtures, sanitaryware, pipework, valves and so on, and illustrates how fresh water is to be supplied into a building and waste water removed. To illustrate the separate hot and cold water supply, the pipe runs will usually be coloured red and blue respectively. Drainage pipes should be illustrated with the grade (slope) indicated. Where manholes are included, a manhole schedule should detail the name, invert level, cover level, and depth.

SYMBOLS.

Plumbing symbols are used when drawing house plans and diagrams. The purpose of these symbols is to indicate where the different elements of your plumbing system are located.



SCALE

Scale drawings allow us to accurately represent sites, spaces, buildings and details to a smaller or more practical size than the original. When a drawing is described as ‘to scale’, it means that each element in that drawing is in the same proportion, related to the real or proposed thing – it is smaller or indeed larger by a particular percentage.

Scaling is a drawing method used to enlarge or reduce a drawing in size while keeping the proportions of the drawing the same. Scales are generally expressed as ratios and the most common scales used in furniture drawing are **1:1**, **1:2**, **1:5**, and **1:10** for reducing and possibly **2:1** for enlarging.

Scaling is used to either:

- **reduce** the drawing in size so that it will fit onto the page, or

- **Enlarge** the drawing in size so that all required details are clearly visible.

Drawings can be scaled up or down using either a calculator or a scale rule.

To scale a drawing using a calculator:

- **divide** the measurement by the scale if you want to **reduce** the drawing in size, or
- **Multiply** the measurement by the scale if you want to **increase** it in size.

Example 1: Scaling down

- A 50mm line is to be drawn at a scale of **1:5** (ie 5 times less than its original size). The measurement **50mm** is **divided** by **5** to give **10mm**. A 10mm line is drawn.

- A 50mm line is to be drawn at a scale of **1:2**. The measurement **50mm** is **divided** by **2** to give **25mm**. A 25mm line is drawn.

Example 2: Scaling up

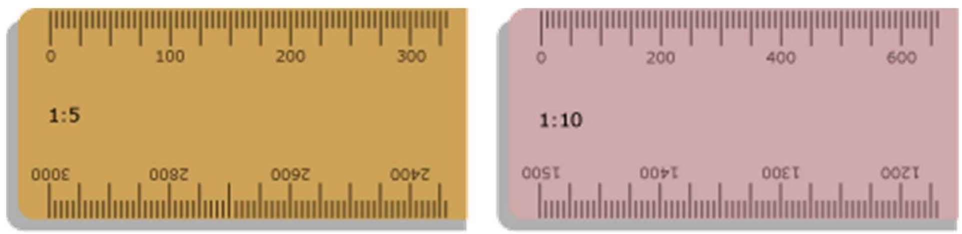
- A 50mm line is to be drawn at a scale of **5:1** (ie 5 times more than its original size). The measurement **50mm** is **multiplied** by **5** to give **250mm**. A 250mm line is drawn.

- A 50mm line is to be drawn at a scale of **2:1**. The measurement **50mm** is **multiplied** by **2** to give **100mm**. A 100mm line is drawn.

To scale a drawing using a scale rule:

Scale rules allow us to directly set out measurements onto a drawing without having to convert them to their scaled sizes by using a calculator first.

The whole process is made easier because these conversions are already made for us. On a scale rule which has divisions of **1:5**, each division represents 5mm and the measurements on the rule indicate this.



On a scale rule which has divisions of **1:10** each division represents 10mm and the measurements on the rule indicate this.

MEASUREMENTS

Measurement is the transformation of drawn information into descriptions and quantities, undertaken to value, cost, and price construction work, as well as enabling effective management.

Imperial measurements

Miles, feet and inches are old units of length. These are known as imperial units of length but are not now commonly used in mathematics. There are 12 inches in a foot. An inch is roughly equal to 2.5 centimeters.

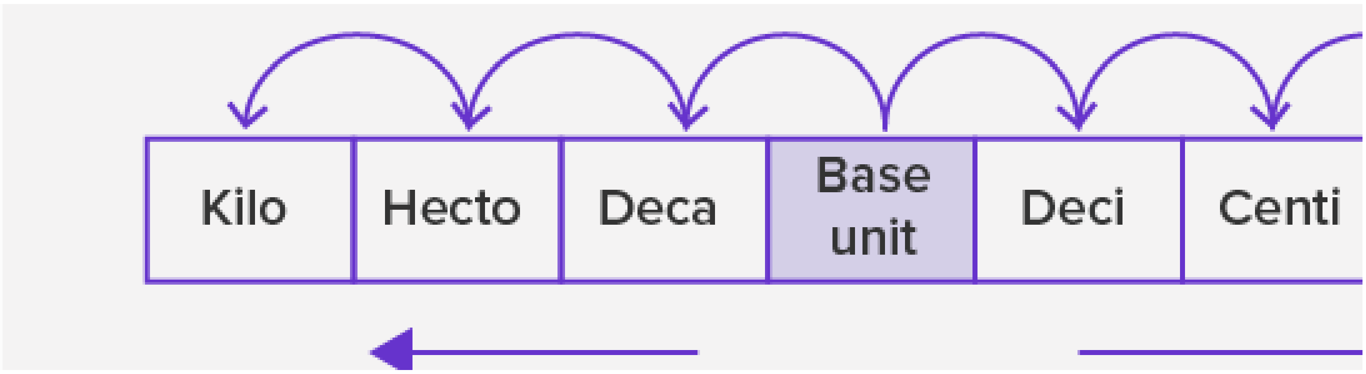
How can you convert imperial measurement to metric measurements?

- 1 foot (12 inches) is equal to 30 centimeters
- 1 inch is about 25 millimeters or 2.54 centimeters
- A 3-foot measurement is almost exactly 1 meter

What is Metric System?

The metric system is a system of measurement that uses the meter, liter, and gram as base units of length (distance), capacity (volume), and weight (mass) respectively.

To measure smaller or larger quantities, we use units derived from the metric units



- The given figure shows the arrangement of the metric units, which are smaller or bigger than the base unit.
- The units to the right of the base unit are smaller than the base unit. As we move to the right, each unit is 10 times smaller or one-tenth of the unit to its left. So, a 'deci' means one-tenth of the base unit, 'centi' is one-tenth of 'deci' or one-hundredth of the base unit and 'milli' is one-tenth of 'centi' or one-thousandth of the base unit.

Linear Measure

10 millimeters (mm) =	1 centimeter (cm)	
10 centimeters =	1 decimeter (dm)	= 100 millimeters
10 decimeters =	1 meter (m)	= 1,000 millimeters
10 meters =	1 dekameter (dam)	
10 dekameters =	1 hectometer (hm)	= 100 meters
10 hectometers =	1 kilometer (km)	= 1,000 meters

Area Measure

100 square millimeters (mm^2) =	1 sq centimeter (cm^2)
10,000 square centimeters =	1 sq meter (m^2)
=	1,000,000 sq millimeters
100 square meters =	1 are (a)
100 ares =	1 hectare (ha)
=	10,000 sq meters
100 hectares =	1 sq kilometer (km^2)
=	1,000,000 sq meters

Volume Measure

10 milliliters (ml) =	1 centiliter (cl)	
10 centiliters =	1 deciliter (dl)	= 100 milliliters
10 deciliters =	1 liter (l)	= 1,000 milliliters
10 liters =	1 dekaliter (dal)	
10 dekaliters =	1 hectoliter (hl)	= 100 liters
10 hectoliters =	1 kiloliter (kl)	= 1,000 liters

Weight

10 milligrams (mg) =	1 centigram (cg)	

10 centigrams =	1 decigram (dg)	= 100 milligrams
10 decigrams =	1 gram (g)	= 1,000 milligrams
10 grams =	1 dekagram (dag)	
10 dekagrams =	1 hectogram (hg)	= 100 grams
10 hectograms =	1 kilogram (kg)	= 1,000 grams
1,000 kilograms =	1 metric ton (t)	

How to Measure Pipe and Fitting Sizes

Convert Actual Diameter to Nominal Diameter

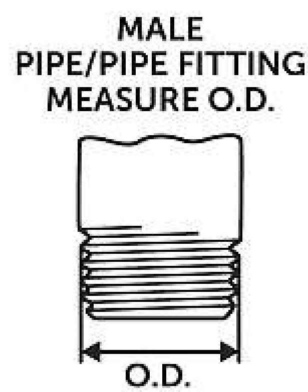
The easiest way to find what nominal pipe size you need is to use follow these steps and use the conversion chart below.

For Male Threads

1. Measure the Outside Diameter (OD) of your pipe or pipe fitting:

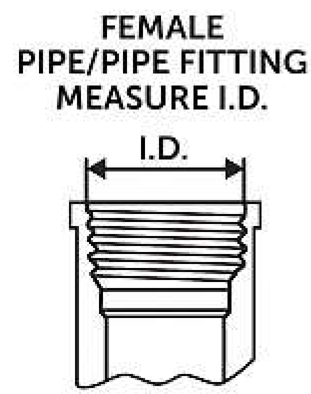
- Wrap a string around the pipe
- Mark the point where the string touches together
- Use a ruler or measuring tape to find the length between the tip of the string and the mark you made (circumference)
- Divide the circumference by 3.14159

2. Use the chart on this page to find the nominal diameter (pipe size).



For Female Threads

1. Measure the Inside Diameter (ID) of your pipe or pipe fitting (use a ruler or tape measure).
2. Use the chart on this page to find the nominal diameter (pipe size).



Nominal Diameter Conversion Chart

(All Measurements in Inches)

Outside or Inside Diameter	**Decimal Equivalent**	**Nominal Diameter**	**Typical Threads Per Inch**
5/16	0.313	1/16	27
13/32	0.405	1/8	27
35/64	0.540	¼	18
43/64	0.675	3/8	18
27/32	0.840	½	14
1-3/64	1.050	¾	14
1-5/16	1.315	1	11-1/2
1-21/32	1.660	1-1/4	11-1/2
1-29/32	1.900	1-1/2	11-1/2
2-3/8	2.375	2	11-1/2

2-7/8	2.875	2-1/2	8
3-1/2	3.500	3	8
4	4.000	3-1/2	8
4-1/2	4.500	4	8

Pipes vs. Tubing

Pipe and tubing are not measured the same way. Tubing is measured and named based on the actual outside diameter of the tube.

PEX, or Cross-Linked Polyethylene Tubing, is another technology fast becoming popular, and it is measured and named by inside diameter.

Example:

Pipe vs. Tubing	**Outside Diameter**
1/2" size pipe	27/32"
1/2" size tubing	1/2"

TYPES OF DRAWINGS

Details and sections

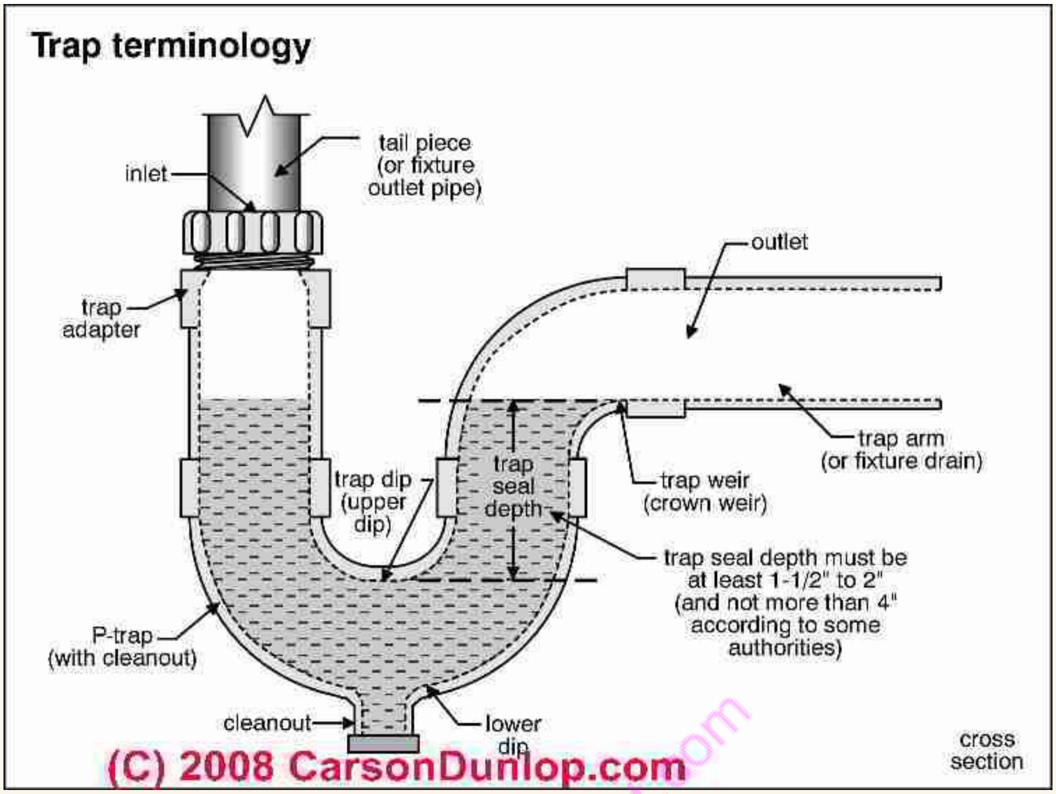
Section view is a view used on a drawing to show an area or hidden part of an object by cutting away or removing some of that object. v The cut line is called a "cutting plane", and can be done in several ways. v The following slides will help show the several methods or types of "section views".

What is a cutting plane?

The place where the building is cut away is called “cutting plane”and the location of the imaginary cutting plane is typically indicated by a cutting plane line that consist of long dashes set off by two shorter ones.

6 TYPES OF SECTIONAL VIEWS

1. **Full sections.** This is the most common section (called a full section) with the imaginary laser cutting a line across the entire construction, offering a view of a portion of the building with the rest of it put to one side.
2. **Half sections or views.** In this type of section, only half of the space or object is cut away. This allows you to see part of it in elevation, while the other part of the drawing gives a glimpse inside.
3. **Offset sections or views.** In an offset section, the cutting plane does not follow a straight line. This might be used, for example, if the architect or engineer wanted to show a section of one room but also the section of another that is located behind it. In other words, while the cutting planes are parallel, the one in one portion of the drawing may be some distance from the plane in another portion.
4. **Broken out sections or broken views.** With these drawings, only a small portion of the object or space is shown in section. Instead of a section line, the portion that is shown in section is indicated by an irregular cut line.
5. **Revolving sections or view.** With this type of section, a space or detail is shown with a cutting plane at an angle, and then the section is rotated so that the cutting plane faces the viewer.
6. **Removed sections.** With a removed section, only a portion of the drawing is shown in section, and this detail is removed to the side. The scale of the section will be different from the main drawing, providing a more detailed perspective.



Cross section.

Line drawing

Different Types of Lines in Engineering Drawing

A single drawing is composed of many basic elements, and different types of lines play distinct roles. A variety of line styles graphically represent physical objects, including visible, hidden, center, cutting plane, section, and phantom. Each style can be divided into different types. Let's see what types of lines used in engineering drawings.

A: **Continuous Thick Line**

This line is used to display the outline and edges of the main drawing, done with a pencil softer than HB.

Continuous Thick Line

B: **Continuous Thin Line**

This line is basically used for dimension, extension, projection, leader line, etc. A harder pencil should be used, such as a 2H pencil.

Continuous Thin Line

C: **Continuous Thin Free Hand Line**

This line is used to show short break or irregular boundaries.


Continuous Thin Free Hand Line

D: **Continuous Thin Zigzag Line**

This line is used to show long break.


Continuous Thin Zigzag Line

E: **Dashed Line**

This line is used to show hidden edges of the main object.

Dashed Line

F: **Chain Thin Line Long-Dotted (Dashed Thin Lines with Dots)**

This line is used to represent the center line for circles and arcs.

Chain Thin Line Long-Dotted

G: **Chain Thin with Thick Ends**

This line is used to represent the location of a cutting plane.

Chain Thin with Thick Ends

H: **Long Thin Dashed and Double Short Dashed Lines**

This line is located in front of cutting planes, outlines of adjacent parts, censorial Lines, and to state center of gravity.

Long Thin Dashed and Double Short Dashed Lines

Free hand drawing is also used to quickly present an idea in a graphical form to non-technical peoples.

Free hand sketching

It improves the communication between all the members of a team and also between the customer. Free Hand Sketching is such a drawing which is drawn without measuring instruments.This drawing is drawn with the help of pencil and eraser only.Such drawing is drawn before every type of actual drawing because it takes less time.After doing such drawing, it is pondered over, and necessary alterations are made in it if needed.Then the actual drawing is prepared.

Free-Hand Sketching Instruments.

Importance of Free Hand Sketching.

Free hand drawing has much importance in practical works because a draftsman has to check the drawings of every object from the engineer.

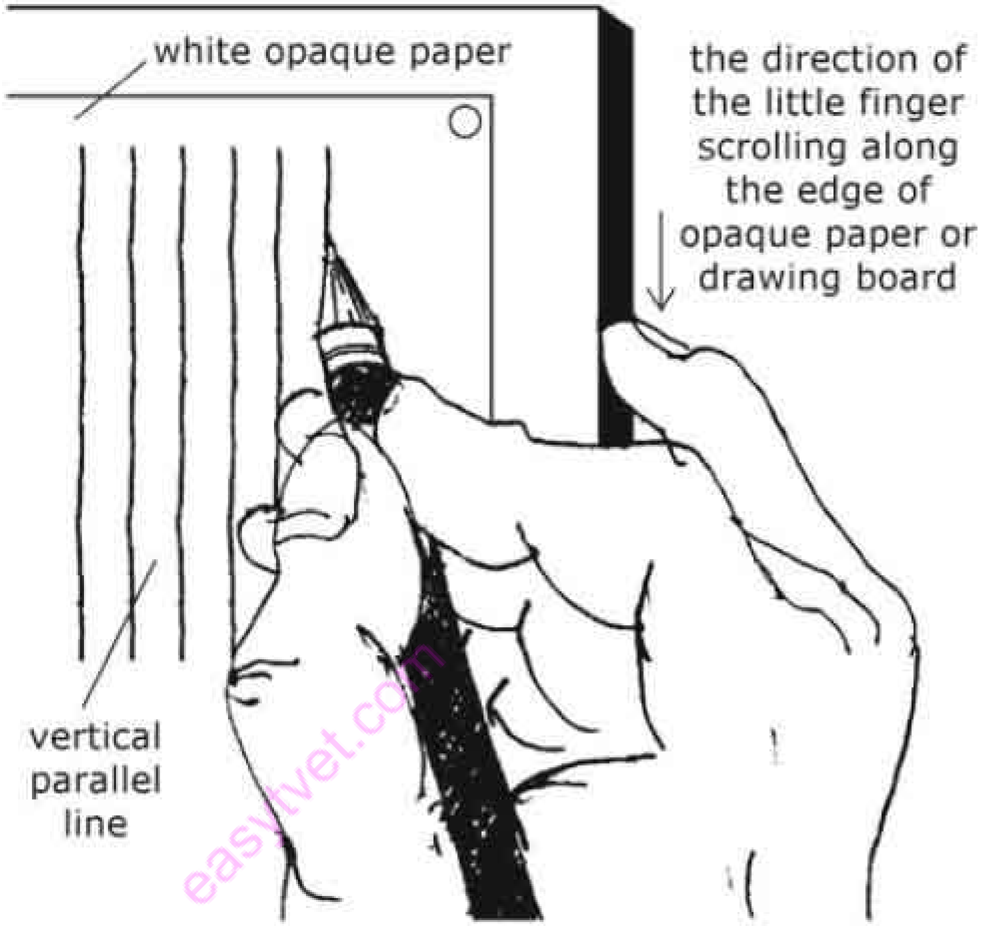
At the checking of complete drawing, much time is wasted on the alterations, if needed.

Sketching of Lines in Free Hand Drawing.

i). Sketching of Vertical Lines.

A vertical line is drawn from the top to the bottom of the drawing sheet.

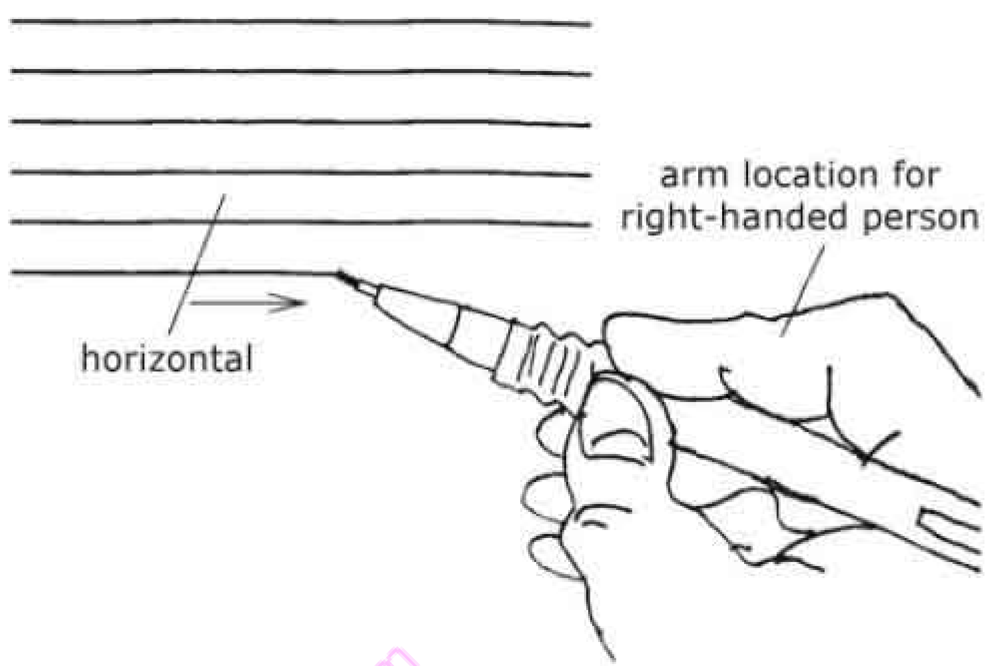
It takes a lot of practice to draw vertical lines.



Holding the pencil when drawing *vertical straight lines* [4]

(ii). Sketching of Horizontal Lines.

When sketching horizontal lines, your hand and forearm should turn at the elbow, and the edge of your hand should slide horizontally on the paper.



Freehand sketching of *horizontal parallel lines*

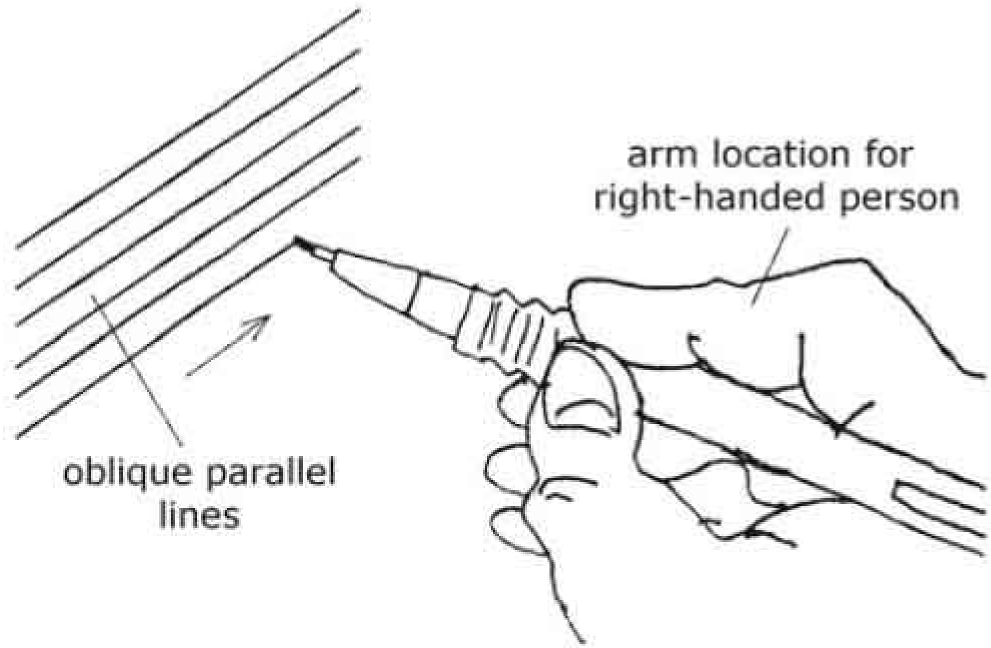
When drawing a horizontal line, you should first try drawing a line in the air to see how the line goes.

Then apply a little pressure on the pencil tip and draw a horizontal line lightly.

(iii). Sketching of Oblique Lines.

The oblique lines are drawn from the one corner of the page to the other diagonally.

Usually, the right-handed people draw sloping or oblique lines from the bottom left to the top right of the paper.

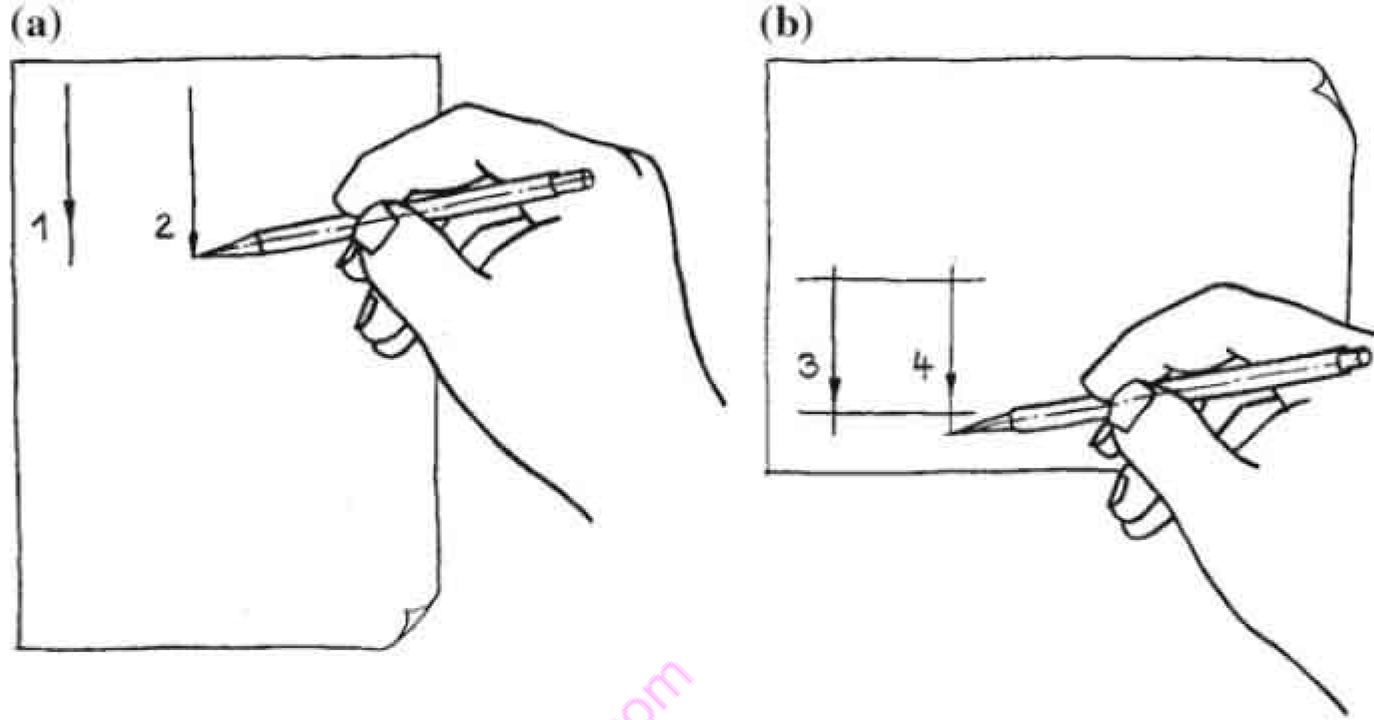


However, the sketching can be made much easier by just rotating the paper into a position where you are going to draw an oblique line.

2. Sketching of Rectangles.

A rectangle is a common shape in technical drawings. To draw rectangles via free hand sketching different techniques are used.

They can be drawn in several ways, but the easiest way to draw a rectangle is by drawing vertical or horizontal lines and rotating the paper at 90 degrees angle.

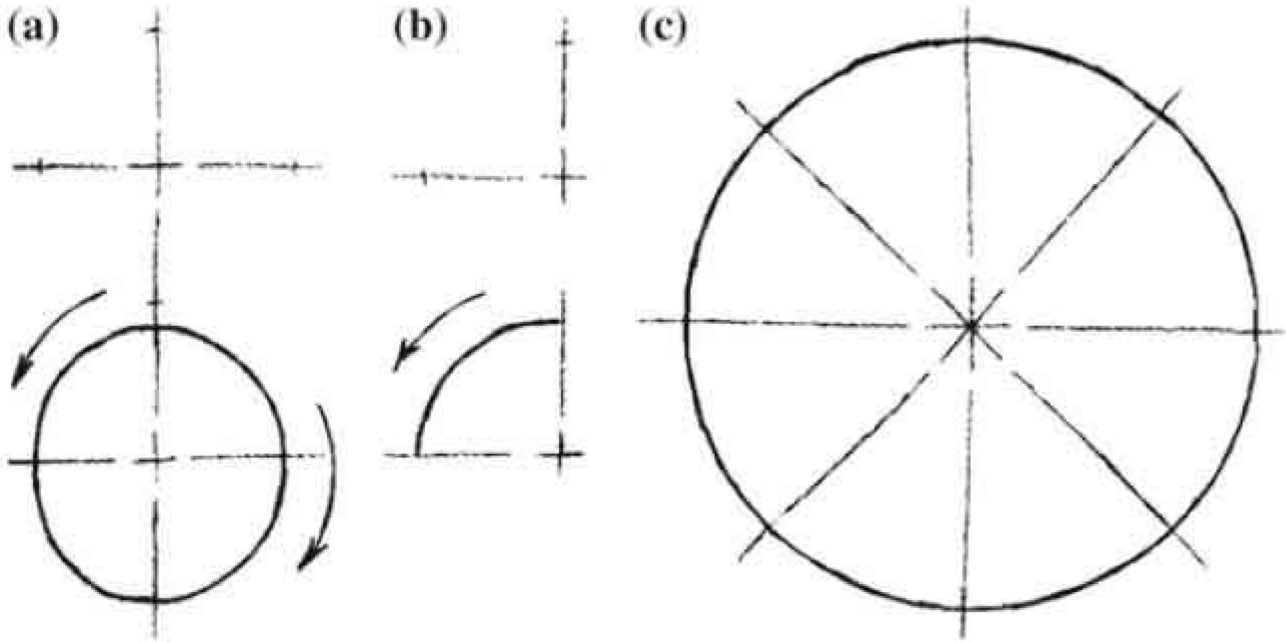


3. Sketching of Curved Lines.

Curved lines in the drawing can be arcs, circles, etc.

To draw a circle, first of all, you should draw a center line and mark it with radii.

Shape the radii points into a box, inside in which you can draw a circle.



Sketching a circle and an arc [19]. Principles: two arcs for small circle (a), sketchi
into clockwise direction (b), larger circle with eight arcs (45 degrees) (c)

First of all, sketch the top-left part of the circle (rotate the pencil in an anti-clockwise direction) then draw the bottom-right part of the circle (rotate the pencil in a clockwise direction).

Pictorial Drawing

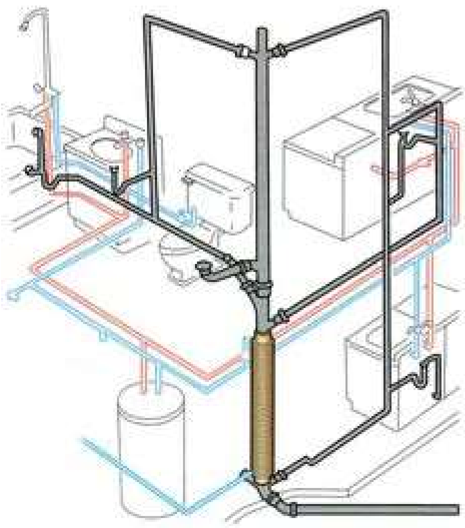
A Pictorial drawing provides a 3D image to help understand the shape of an object or to assist in interpreting a drawing. There are 3 main ways to draw a pictorial drawing,

1. Isometric, 2. Oblique, 3. Perspective.

(Other methods of Pictorial drawings include dimetric drawing, trimetric drawing)

1.Isometric drawing

Definition – An Isometric drawing is a pictorial representation of an object in which all three dimensions are drawn at full scale. The term isometric means “equal measurement”.



Isometric drawings

The isometric is one class of orthographic projections. (In making an orthographic projection, any point in the object is mapped onto the drawing by dropping a perpendicular from that point to the plane of the drawing.) An isometric projection results if the plane is oriented so that it makes equal angles (hence "isometric," or "equal measure") with the three principal planes of the object. Thus, in an isometric drawing of a cube, the three visible faces appear as equilateral parallelograms; that is, while all of the parallel edges of the cube are projected as parallel lines, the horizontal edges are drawn at an angle (usually 30°) from the normal horizontal axes, and the vertical edges, which are parallel to the principal axes, appear in their true proportions.

Stage 1: Construction

This should be done with a hard pencil (3H), used lightly, and the strokes with the pencil should be rapid. Slow movements produce wavy, uncertain lines. Since these constructed lines are very faint, errors can easily be erased.

Stage 2: Lining in

Carefully line in with a soft pencil (HB), following the construction lines drawn in stage 1. The completion of stage 2 should give a drawing that shows all the details and you may decide, particularly in an examination, not to proceed to stage 3

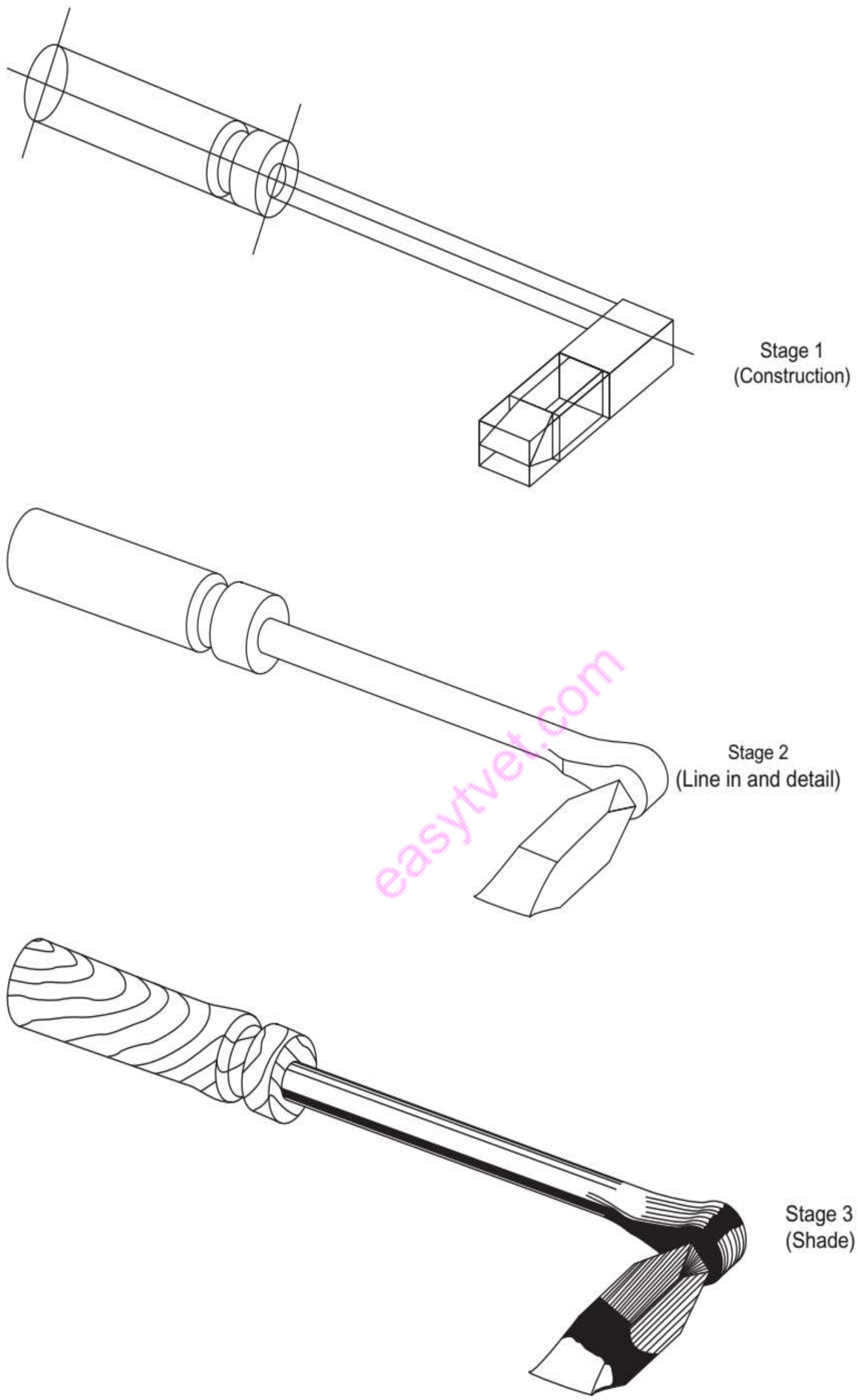
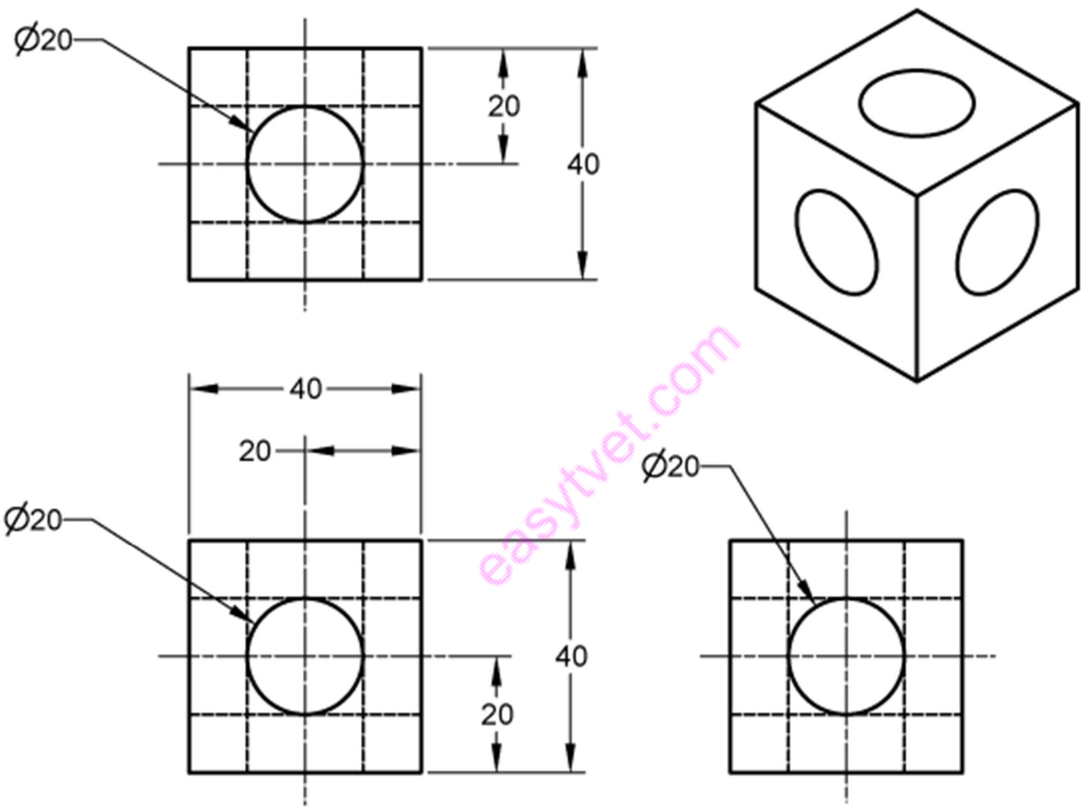


Figure 162 3 stages of freehand sketching

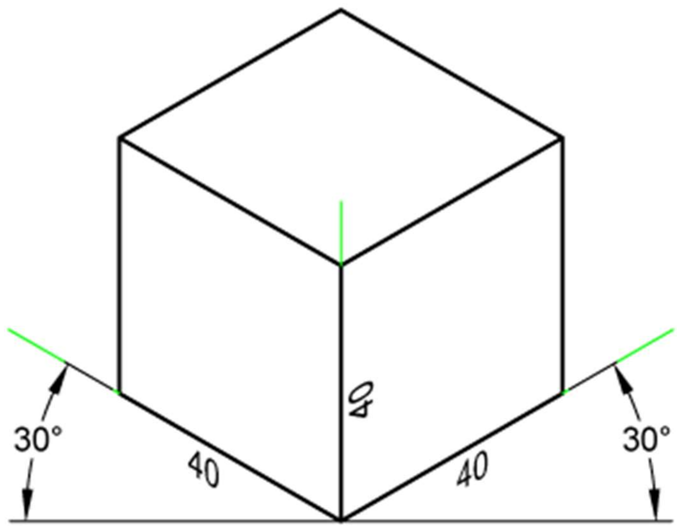
Stage 3: Shading

Drawing Circular Features

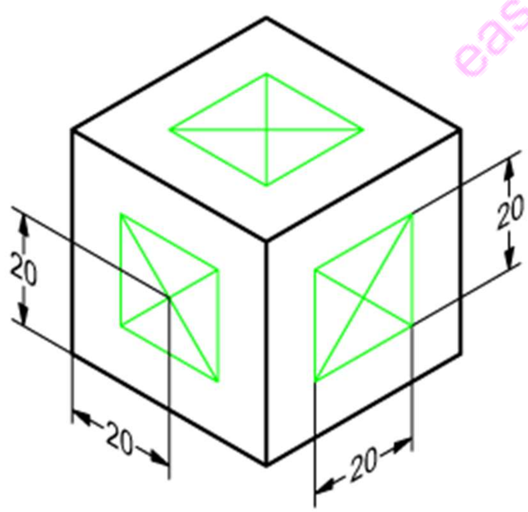
Circular features of an object appear as ellipses on an isometric pictorial.



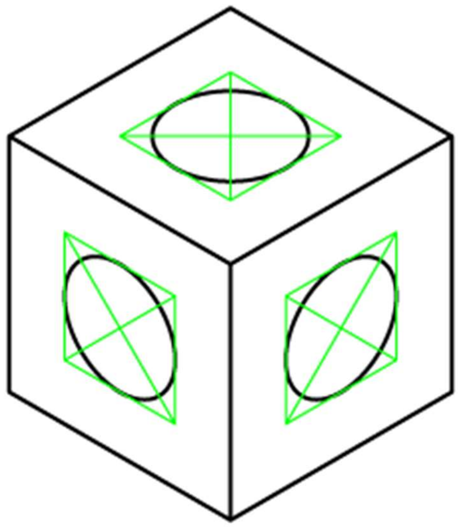
Step 1) Draw the linear features of the object using the procedure previously described.



Step 2) Draw a box whose diagonals meet at the center of the circle and the length of the sides are equal to the circle's diameter.



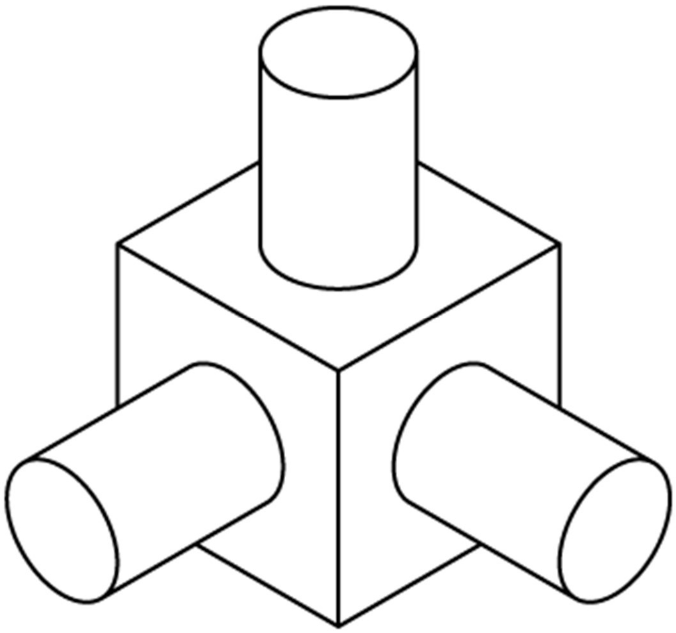
Step 3) Draw an ellipse in the box whose major axis is aligned with the long diagonal of the box. The ellipses touch the box at the midpoint of its sides.



The same procedure is used for creating radii except that the unwanted part of the ellipse is erased or trimmed.

Cylindrical Features

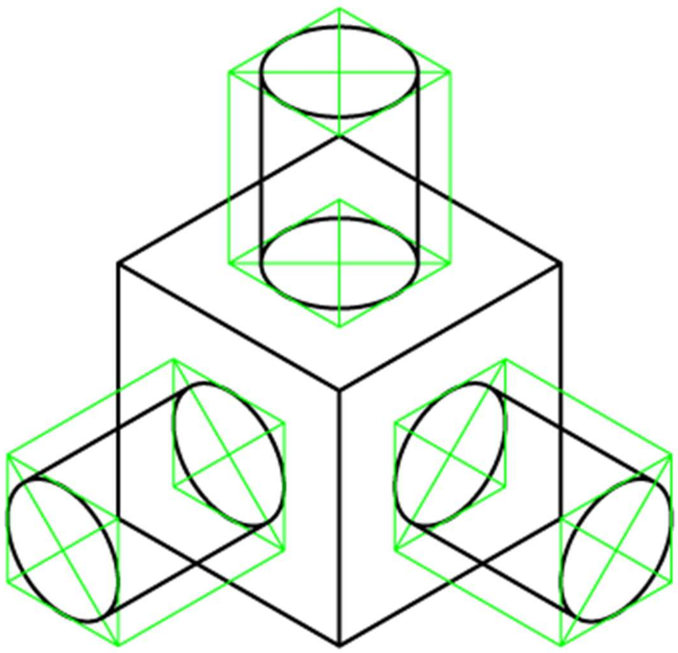
Drawing cylinders in an isometric pictorial is just a matter of drawing two circles and adding some connecting lines.



Step 1) Draw a defining box. The height is equal to the height of the cylinder and the width and depth are equal to the diameter of the cylinder.

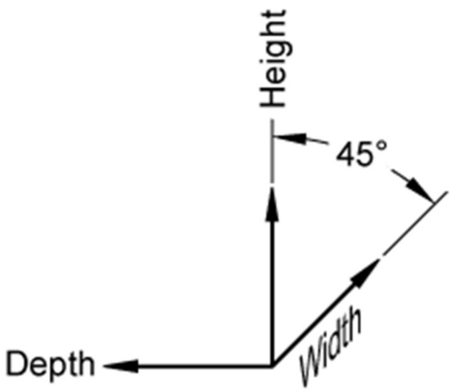
Step 2) Draw diagonals and ellipses in boxes that define the beginning and end of the cylinder.

Step 3) Draw two lines that connect the two ellipses. The lines will start and end at the intersection between the ellipse and the major axis diagonal.



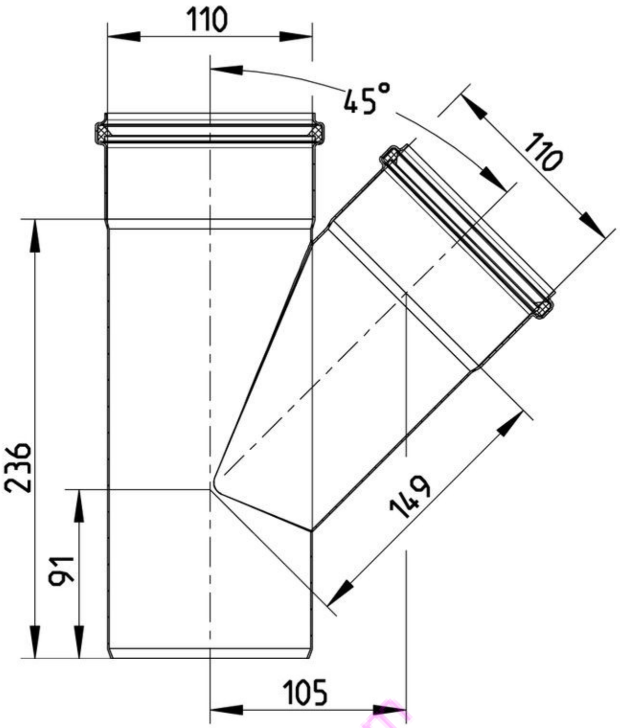
Oblique Axes

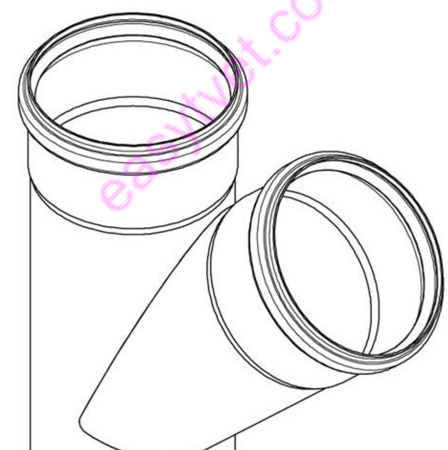
Oblique pictorials are drawn in a coordinate system where only one axis is at an angle from the horizontal. The angle of this axis may range between 0 and 90 degrees; however, the most commonly used angle is 45 degrees.



Oblique axes

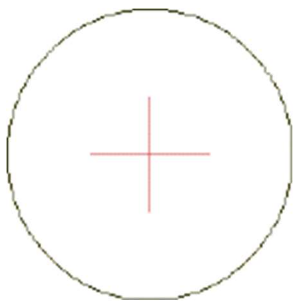
The features drawn on the plane defined by the vertical and horizontal axes are drawn at full scale and true shape. The linear features drawn on the angled axis may be full scale (cavalier projection) or may be drawn foreshortened. The most common, is half scale (cabinet projection, as shown in the figure).



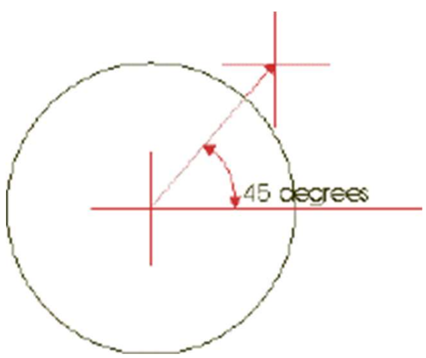


OBLIQUE PROJECTION - DRAWING CYLINDERS

Drawing cylinder in oblique projection ius quiet simple if the stages outlined below are followed.In comparison with other ways of drawing cylinders(for example,perspective and isometric)using oblique projectin is relatively easy.

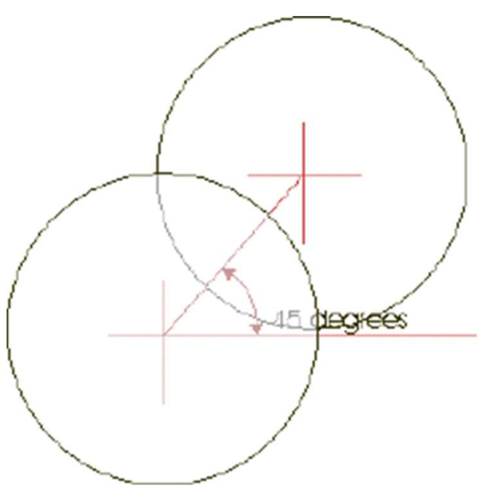


STAGE ONE: Draw a vertical and horizontal centre lines to indicate the centre of a circle, then use a compass to draw the circle itself.

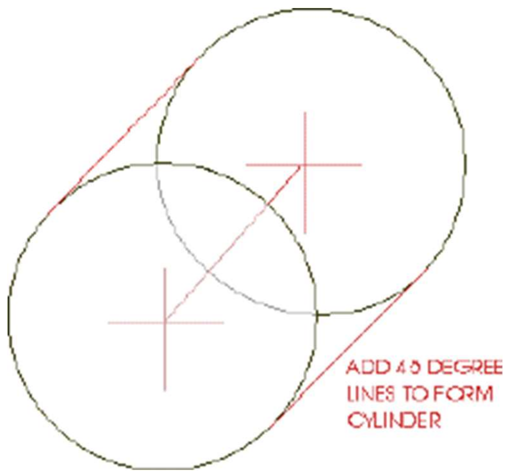


STAGE TWO: Draw a 45 degree line to match the length on the cylinder. At the end of this line draw vertical and horizontal centre lines.

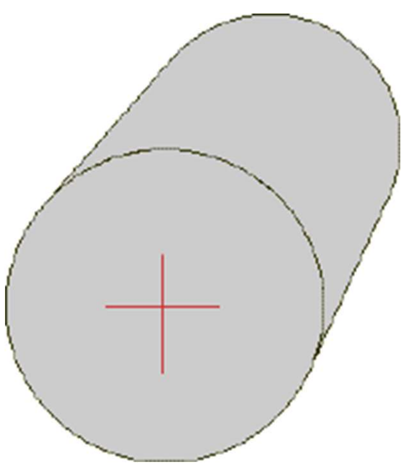
Remember the general rule for oblique is to half all distances projected backwards. If the cylinder is 100mm in length the distance back must be drawn to 50mm.



STAGE THREE: Draw the second circle with a compass.



STAGE FOUR: Draw two 45 degree lines - to join the front and back circles.



STAGE FIVE: Go over the outline of the cylinder with a fine pen or sharp pencil. Add shade - if required.

Isometric Pipework Drawings

Piping isometric drawing is an isometric representation of single pipe line in a plant. It is the most important deliverable of piping engineering. Piping fabrication work is based on isometric drawings.

Piping isometric drawing consists of three sections. Main graphic section consists of isometric representation of a pipe line route in 3D space, which includes following information:

i. Line number.
ii. Flow Direction.
iii. Support Tags and location.
iv. Piping Components location.
v. Weld Locations.

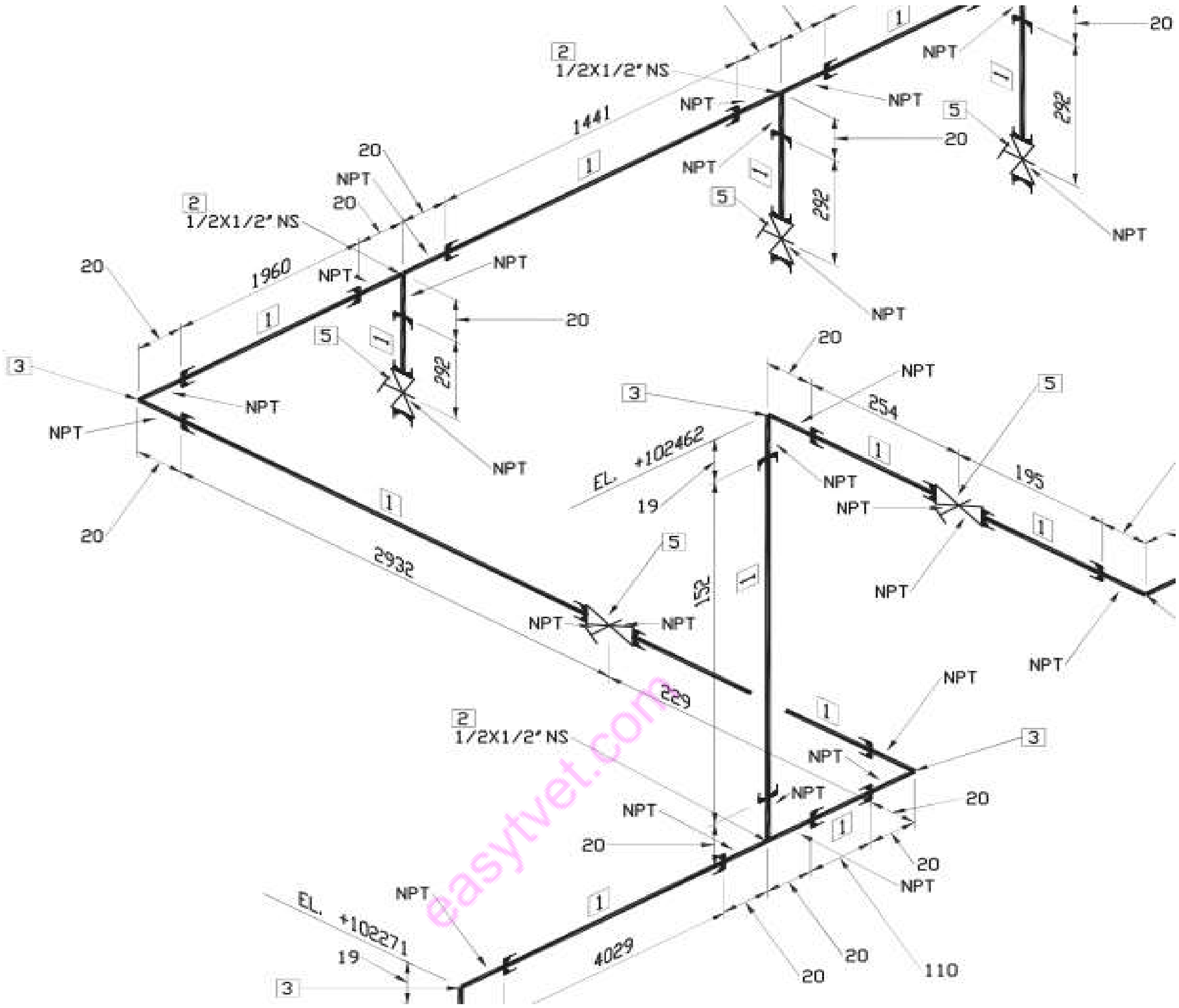
Section on left or right side of drawing consists of Bill of Material Section for the portion of line shown in isometric graphic. It includes following information for all components:

i. Component description.
ii. Component material code.
iii. Nominal size.
iv. Quantity.
v. Whether shop material or field material.
vi. Number of spools.

Title bar section at the bottom consists of following information:

- Project details such as client name
- Engineering office name
- Project name
- Project number

Figure 163: A pipework isometric drawing



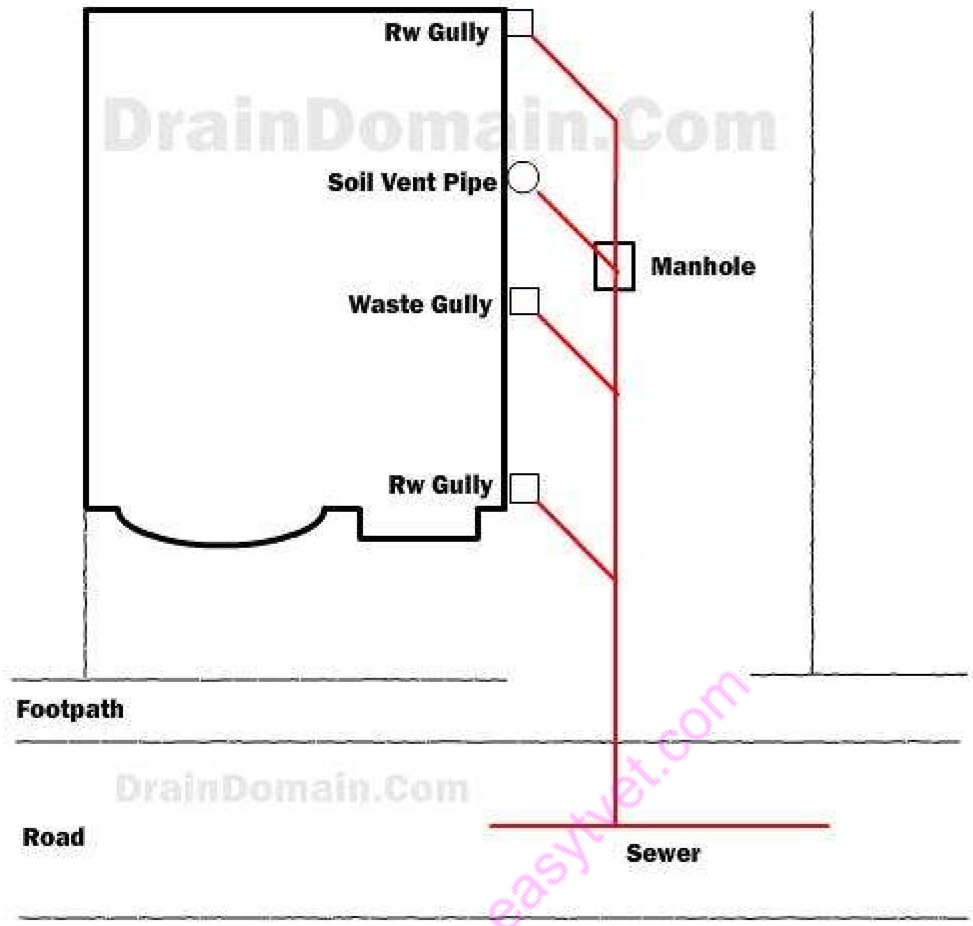
Perspective drawing

Perspective Drawing is a technique used to represent three-dimensional images on a two-dimensional picture plane.

There are three important tools for perspective drawing:

The horizon line; the horizon line appears to us as a clear separation between the ground and the sky.

Vanishing points and vanishing lines; is where all parallel lines intersect and is always on the horizon line.



Types of perspective drawing

There are typically three types of perspective drawing: one-point perspective, two-point perspective, and three-point perspective.

One-point perspective:

One-point perspective is often used for compositions that look at objects from the front. Lines extending from the foreground to the background gather (converge) at one point. The point of convergence is called the “vanishing point”.

The vanishing point will always be on the horizontal line, or “eye level” of the scene, which represents the height of the eye or camera of the observer.

Two-point perspective:

Two-point perspective is used for compositions that look at objects at an angle. As it is close to what the human eye normally sees, it is the most used perspective when drawing manga backgrounds and illustrations.

In one-point perspective, lines converged on one point from the background to the foreground. In two-point perspective, in addition to depth, lines representing width also converge.

Three-point perspective:

Three-point perspective is used for drawing compositions that are looking up at a large object or looking down from a high place.

3.2.1.4 Learning Activities

Create Piping Isometric Drawings

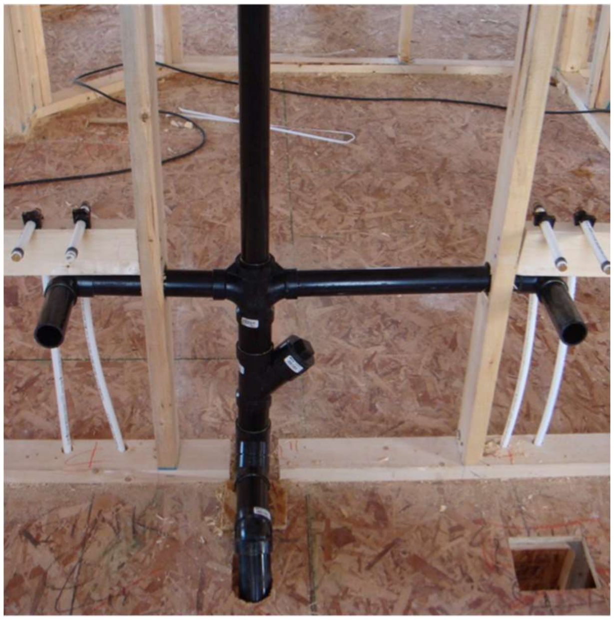
Have students create an isometric drawing based on an existing system of pipe. See below for sample pictures and drawings that could be created. As students gain skill, more complex systems could be shown and drawn.

Teacher Notes

- The shoulders of the fittings are drawn parallel to the opposing outlet.

- In terms of classroom management, it is likely easiest to show pictures of small systems on a projector rather than guiding students to draw isometrics in a lock-step format.

Below are sample piping arrangements and the isometrics that would represent them.



Materials Required

- Scale rule
- Pencils
- Eraser
- Drawing paper
- Drawing board
- T-square

3.2.1.5 Self-Assessment

1. Define the following;
   - **i.** Working drawings
   - ii. Bills of quantities
2. Which are the three types of perspective drawing?
3. There are 3 main ways to draw a pictorial drawing, name them.
4. List the instruments needed for the drawing of free hand sketching.
5. State where the following types of lines are used**;**
   - i. Continuous thick line
   - ii. Continuous thin line
   - iii. **Continuous Thin Zigzag Line**

3.2.1.6 Tools, Equipment, Supplies and Materials

May include but not limited to:

i. Drawing boards
ii. T squares
iii. Set squares
iv. Drawing sets
v. Drawing paper
vi. Protractors
vii. Eraser Shield
viii. Pencils
ix. Erasers
x. Masking tapes
xi. Paper clips
xii. Drawing curves
xiii. Technical drawing software

3.2.1.7 References

- Mays, L., 2001. Water resources engineering. New York: Wiley.

- Cauldwell, R., 2005. Remodel plumbing. Newtown, CT: Taunton Press, pp.24-35.
- Blower, G., (2007). Plumbing. Welwyn Garden City: Pearson Education UK.
- Rendow Yee., (2002). Architectural drawings: a visual compendium of types and methods.
- Thompson., (2007). Architectural design procedures, Second Edition. Architectural Press
- https://en.wikipedia.org/wiki/Water_distribution_system

3.2.1.8 Model answers.

1. **Define the following;**
   i. **Working drawings -** A comprehensive set of drawings used in a building construction project.
   ii. **Bills of quantities**- is a measure or price of the amount of materials and labor and other items required for the building work.
2. Which are the three types of perspective drawing?
   i. **One –point perspective**
   ii. **Two-point perspective**
   iii. **Three –point perspective.**
3. There are 3 main ways to draw a pictorial drawing, name them.
   i. **Isometric**
   ii. **Oblique**
   iii. **Perspective**
4. List the instruments needed for the drawing of free hand sketching.
   i. **Soft Lead Pencil.**
   ii. **Eraser.**
   iii. **Sharpener.**
   iv. **Drawing Sheet.**
   v. **Graph Sheet.**
5. State where the following types of lines are used**;**
   i. **Continuous Thick Line**

This line is used to display the outline and edges of the main drawing, done with a pencil softer than HB.

ii. **Continuous Thin Line**

This line is basically used for dimension, extension, projection, leader line, etc. A harder pencil should be used, such as a 2H pencil.

iii. **Continuous Thin Zigzag Line**

This line is used to show long break.

3.2.2 Learning outcome 2: Quantify drainage materials

3.2.1.1 Introduction to the learning outcome

This learning outcome is important when selecting components and provides a description of the various types of pipes, fittings, and joining methods used in drainage systems. Then a detailed description is given of the components, including cleanouts, drains, interceptors, traps, and valves, which permits selection of the most appropriate components for a given installation.

3.2.1.2 Performance Standard

1. Drainage materials and supplies are identified based on the drawings and specifications.
2. Materials are estimated based on drawings and specifications
3. Materials cost estimates are calculated from the market rates
4. A schedule of materials is developed based on the drawing.

3.2.1.3 Information Sheet

Definitions of terms

- **Fittings** are any pipe parts used to join two sections of pipes.

- **A plumbing fixture** is an exchangeable device which can be connected to an existing plumbing system to enable a particular use.
- **Specification** is a precise description of the materials and methods of workmanship to be employed while carrying out the contract work
- **Schedules** give tables of information on ranges of similar item.
- **Bills of quantities-**is a measure or price of the amount of materials and labour and other items required for the building work.

Drainage Materials and Supplies

Materials for Drain Pipe

The materials used for manufacturing drain pipes are clay, concrete, and plastics. Important criteria for pipe quality and for selecting the most suitable type of pipes are: resistance to mechanical and chemical damage, longevity, and costs .Mechanical damage and chemical deterioration may occur during transport and handling, or after the pipe has been installed. In addition, the lifetime of the pipes should not be excessively shortened by deterioration in mechanical or chemical properties in the course of time. The costs are the total costs for purchase, transport, handling, and installation.

The selection of components and materials for pipes and fittings in drainage system installations depends on various factors which include;

- **Total installed cost**. This includes the cost of the pipe and fittings, assembly of the joints, handling, allowance for physical damage, and the cost of the support system for the piping.
- **Corrosion resistance of the pipe and fittings**. This is a measure of the ability of the pipe and fittings to resist both the internal corrosive effects of the effluent likely to flow through them and the effects of soils on their exteriors. Corrosion can be reduced or eliminated by the application of a suitable coating and lining.
- **Physical strength of the pipe and fittings**. This is a measure of the ability of the pipe and fittings to resist physical damage that may occur either during installation or after being placed in service.
- **Fire resistance of the pipe and fittings**. This is a measure of the ability of the pipe and fittings

a) to remain intact and not fail during a fire and
b) To retain the ability to carry water during a fire.

Drainage materials and supplies include;

1. **Pipes**

Pipes used in drainage systems can be either Metallic or Plastic pipes.

i. **Metallic Pipes**

a) **Cast-iron (Cl) Soil Pipe**

Also known as gray cast-iron pipe, is a pipe fabricated of an iron alloy containing carbon and It is manufactured in three classifications: service (standard) weight, extra heavy weight, and hubless. This pipe usually is lined internally with cement or coal-tar enamel and is coated externally with a variety of materials to reduce corrosion by soils. Cast iron is well suited for use in any part of a drainage and vent system.

Its advantages include the ability to withstand moderate external pressure (such as that resulting from burial in soil), good fire resistance, low flow resistance, and good corrosion resistance in most soils. Some piping of this type has been in use for over 100 years.

Disadvantages include brittleness (it is subject to breakage when roughly handled), low corrosion resistance in aggressive soils and to highly septic effluent, heavy weight, and high initial cost.

b) **Acid-Resistant Cast-Iron Pipe (AR)**

Acid-resistant cast-iron pipe, commonly called high-silicon iron pipe, is a gray cast-iron alloy containing between 4.25 and 15 percent silicon and small amounts of manganese, sulfur, and carbon. It is manufactured in the same dimensions as cast-iron pipe, but only in the extra heavy weight. It is available with two types of pipe ends: hub and spigot or hubless. The hub-and-spigot ends can be joined by caulking. Hubless pipe is joined by compression couplings. Acid resistant cast-iron pipe is used for drainage of corrosive liquids and in exposed or underground applications where it may be subject to physical damage.

c) Ductile-Iron Pipe

Ductile-iron pipe is fabricated of a cast-iron alloy in which graphite replaces the carbon that is present in cast-iron oil pipe.' It is available for use either as a gravity sewer pipe or as a pressure pipe in sizes ranging from 3 to 54 in (8 to 135cm) as well as gravity sewer pipe. A cement or bituminous pipe lining can be provided to resist internal corrosion. This type of pipe can be assembled with mechanical joints, gasketed joints, or flanged joints.

The advantages of this type of pipe arc the same as those for cast-iron pipe. It has the additional advantage of a higher-pressure rating and higher external loadbearing capacity. It is not as brittle as cast-iron pipe, permitting rougher handling. Its initial cost is higher than that of cast-iron pipe, though.

d) Steel Pipe

Steel pipe is manufactured in a large number of alloys. It is produced either by extrusion (seamless) or by welding. It is available either plain (black) or galvanized (zinc-plated on the inside, outside, or both). Its wall thickness is expressed as a schedule, with thicknesses ranging from Schedule 10 (lightest) to Schedule 160 (heaviest). The relationship between schedule and wall thickness depends on the pipe diameter. Steel pipe can be obtained with threaded ends (for screwed fittings), plain ends, and beveled ends (for welding). Steel pipe is used for vent systems, for gravity drainage systems where human waste is not discharged, for indirect waste lines, and for pressure piping. Advantages of steel pipe include its availability in long lengths, its availability in varying pipe thickness to meet almost any design pressure, and high internal and external strength.

It has good flow characteristics, good fire resistance, and a low initial cost. A disadvantage is its low corrosion resistance, which results in the need for internal and external corrosion protection-galvanization being the most commonly used method of such protection.

e) Copper Tube

Copper tube used in drainage systems is classified as type DWV (drainage, waste, and vent). It is a seamless tube made from almost pure copper (99.9 percent) and is available only in drawn, or soft, form with plain ends. Joints for this pipe can be either soldered or brazed. Soldering provides adequate strength; it is also less. The pipe is available in diameters from 2 to 6 in (5 to 15 cm). It is primarily used in residential buildings for waste lines and in larger buildings, for local branch lines where human waste is not discharged.

Its advantages include light weight, ease of assembly, and a smooth interior. Its disadvantages include corrosive attack by ordinary sewage, poor fire resistance, and the need for dielectric connections to eliminate galvanic corrosion where this material is connected to iron piping.

f) Brass Pipe

Brass pipe is manufactured from an alloy containing 85 percent. copper and 15 percent zinc. For drainage systems, tubing having plain ends is used. Joints can be either screwed or soldered. Brass pipe is generally used in local branch drainage lines (where this alloy resists specific corrosive drainage effluent) and in alterations to match existing work. The advantages and disadvantages of brass pipe are the same as those for copper tubing, except that brass can be used as a drain pipe under pressure.

g) Lead Pipe

Lead pipe is made from 99.7 percent pig lead; various alloys also are available for special applications. This pipe is joined by wiped joints, burned joints, or flanged mechanical joints. Lead pipe is used for connections to floor-mounted water closets, for radioactive wastes, and for special laboratory corrosive wastes. It is rarely used in modern drainage systems.

1. PLASTIC PIPE

Plastic pipe is fabricated in a great variety of compositions, many of which are suitable for drainage and vent systems. The applicable code is usually the most important factor in determining the use and selection of plastic pipe for such purposes.

Plastic pipe is manufactured in two general types:

- thermoset (TS) and
- Thermoplastic (TP).

Thermoset piping (for example, epoxy and phenolic) is not affected by heat and will remain permanently rigid. It is more resistant to solvents than thermoplastics. Thermoplastic piping softens when subject to heat and rehardens

upon removal of the heat. This process of heating and subsequent rehardening affects the strength of the pipe. Therefore, the selection of plastic pipe must be closely coordinated with the pipe hangers and pipe support system. The advantages of plastic pipe in drainage and vent systems include;

- ✓ excellent resistance to a very wide range of sanitary and chemical effluents
- ✓ resistance to aggressive soils, availability in long lengths
- ✓ low resistance to fluid flow
- ✓ low initial cost.

Disadvantages include;

- ➢ poor structural stability (requiring additional support)
- ➢ susceptibility of some types of plastics to physical changes resulting from exposure to sunlight
- ➢ low resistance to solvents, poor fire resistance
- ➢ lowered pressure ratings at elevated temperatures
- ➢ Production of toxic gases which are released upon combustion of some types of plastic pipe.

a) Polyvinyl Chloride (PVC) Pipe

Polyvinyl chloride pipe (type TS) is available in Schedules 40 and 80 and in diameters up to 20 in (50 cm). Drainage fittings are made in diameters up to 8 in (20cm). Schedule 80 pipe can be joined either by threading or solvent welding, but Schedule 40 pipe can only be joined by solvent welding because it cannot be threaded. This pipe will not burn and is self-extinguishing. However, when subject to conditions of a fire, a toxic gas is developed. PVC is the plastic having the highest mechanical strength and is the plastic most widely used for plastic pipe, but it has very poor resistance to solvents.

b) Polypropylene (PP) Pipe

Polypropylene pipe (type TP) is available in Schedules 40 or 80 and in diameters up to 8 in (20 cm). Joining by heat fusion is recommended. This material is one of the more widely used plastics for drainage piping systems. It is capable of withstanding a wide range of both corrosive and sanitary waste. It is the most resistant to solvents of all the common plastic pipe materials and is only slightly less rigid than PVC..

c) Polyethylene (PE) Pip

Polyethylene (PE) PE pipes and fittings of numerous types and designs have been available for over forty years. The market requirements today have been refined to three general groupings, as follows:

i. **High-density PE** is available in a post-manufactured stress-relieved state (bestpractice PE), or as extruded product with no treatment. It is used mainly for drainage applications where it can withstand higher temperature discharges than PVC. To avoid ovality and installation problems when laying to grade the pipe is best used in straight lengths, normally up to 6 metres long. Jointing is achieved by electrofusion or

ii. **Medium-density PE** is more flexible than the high-density pipe. It has a slightly thinner wall thickness and is capable of withstanding higher internal pressure. It is the preferred material for long-distance drinking-water piping. Because of the application and the robust nature of the material it is generally available in coils of up to 200 metres (650 feet) length, depending upon the diameter. The method of jointing is the same as for high-density PE pipe. In colder climates coiled polyethylene piping can be very difficult to use and may be impractical.

iii. **Low-density PE** is suitable for the irrigation industry, where operating pressures are very low and a high degree of flexibility and low cost is required. Low-density PE pipe and fittings are not acceptable for use for connection to the water mains in many countries because of the low pressure rating of the material and its high leakage rate.

d) Acrylonitrile Butadiene Styrene (ABS) Pipe

Acrylonitrile butadiene styrene (type TP) is available in Schedules 40 and 80 and in diameters up to 12 in (35 cm). Drainage fittings are available only in diameters up to 6 in (15 cm). Joints are made by either solvent welding or threaded connections. Only Schedule 80 can be threaded. Acrylonitrile butadiene styrene (ABS) is slightly more rigid than PVC and is the least resistant to solvents of all the popular plastic materials.

Fittings in Drainage Systems

Codes require that any change in direction of piping in a drainage system be made with fittings. The bends in fittings used in drainage systems should have a radius of curvature large enough to prevent solids from accumulating

and to provide good hydraulic flow characteristics. Fittings that satisfy these characteristics are known as drainage-pattern fittings or sanitary-type fittings; they are required by code to be used in drainage systems.

a) Bends (Sweeps).

Is a fitting used to change the direction of a pipe. Fittings are available with changes at various angles. A bend is a 90^0 fitting; it is available as either a short or long sweep (i.e., short or long radius of curvature).

b) Wye.

A wye is a fitting used to connect a branch pipe into a straight run of piping at a 45" angle. Wyes are available with end connections that are of the same size or with various combinations of reduced pipe sizes in any direction.

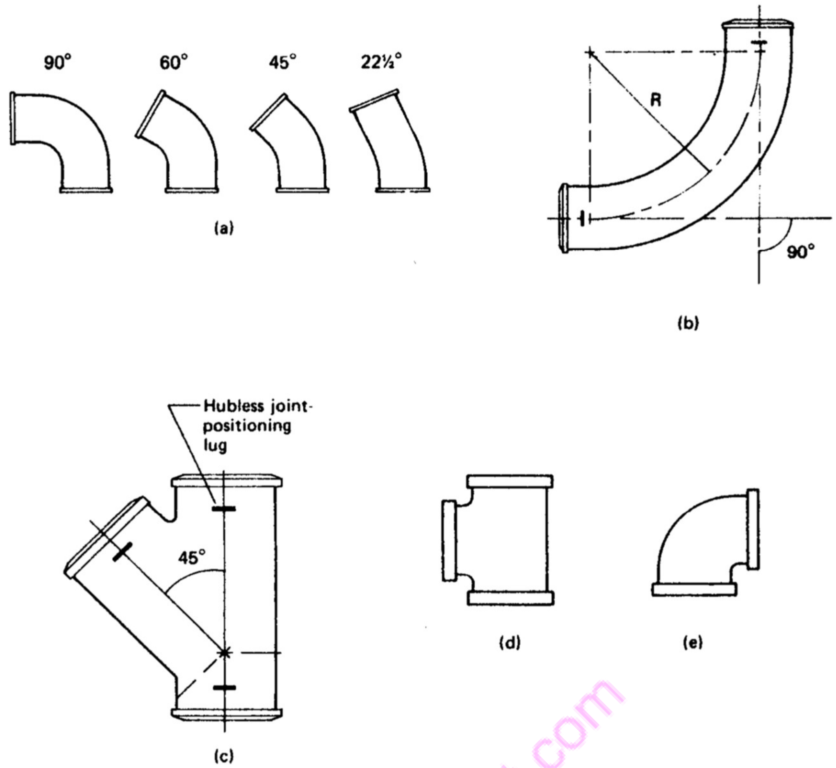
c) Tee.

A tee is a fitting used to connect a branch pipe into a straight run of piping at a right angle. Where flow characteristics are important, such as in the drainage system, codes require that a sanitary tee be used. Where flow is not a consideration, such as in a vent system, standard tees are permitted. They are available with end connections of all similar sizes or in various combinations of reduced pipe sizes in any direction.

d) Elbow.

An elbow is a fitting having a 90" change of direction with a very short radius. It is only suitable for use in vent systems.

Fig 1.4: ***Typical sanitary fittings. (a) 90'. 60°, 45', and $22^{1/2}$" bends; (b) 90' sweep; (c) 45' sanitary tee; (d) standard tee; (e) elbow.***



PIPE SCHEDULES

What are Pipe Schedules?

The schedule number on pipe products relates to the thickness of the wall on the pipe: as the number increases, the thicker the wall thickness becomes. Also, while the schedule number can be the same on different sized pipes, the actual wall thickness will be different. Here are a few

examples:

Pipe size 1.000" Schedule 40 – The actual wall thickness is 0.133"

Pipe size 2.000" Schedule 40 – The actual wall thickness is 0.154"

Pipe size 1.000" Schedule 80 – The actual wall thickness is 0.179"

Pipe size 2.000" Schedule 80 – The actual wall thickness is 0.218"

What we can see here is that the schedule number increases the wall size, and that the wall thickness changes based on the nominal pipe size (NPS).

The best way to see the relationship between pipe size, schedules and wall thicknesses is simply to refer to a conversion chart (below):

PIPE SCHEDULES & WEIGHTS					
		SCHEDULE 40		SCHEDULE 80	
NOMINAL PIPE SIZE	OUTSIDE DIAMETER	Wall Thick.	Wt. Per Ft.	Wall Thick.	Weight Per Ft.
1/8	0.405	0.068	0.245	0.095	0.315
1/4	0.540	0.088	0.425	0.119	0.535
3/8	0.675	0.091	0.568	0.126	0.739
1/2	0.840	0.109	0.851	0.147	1.088
3/4	1.050	0.113	1.131	0.154	1.474
1	1.315	0.133	1.679	0.179	2.172
1-1/4	1.660	0.140	2.273	0.191	2.997
1-1/2	1.900	0.145	2.718	0.200	3.631
2	2.375	0.154	3.653	0.218	5.022
2-1/2	2.875	0.203	5.793	0.275	7.661
3	3.500	0.216	7.576	0.300	10.250
3-1/2	4.000	0.226	9.109	0.318	12.510
4	4.500	0.237	10.790	0.337	14.980
5	5.563	0.258	14.620	0.375	20.780
6	6.625	0.280	18.970	0.432	28.570
8	8.625	0.322	28.550	0.500	43.390
10	10.750	0.365	40.480	0.500	54.740
12	12.750	0.375	49.560	0.500	65.420

There are several schedule numbers used on pipe, such as schedules: 5, 5S, 10, 20, 30, 40, 60, 80, 100, 120, 140, 160, STD, XS and XXS. The most common ones used are schedules 40 and 80

What does Nominal Pipe Size or NPS mean?

The NPS size represents the approximate inside diameter (not outside) of the pipe; if the schedule number on a set size is changed, it does effect the inside diameter (ID) but not the outside diameter (OD). In 1927 the American Standard Association replaced the previously used Iron Pipe Sizing (IPS) with Nominal Pipe Sizing (NPS). This North American standard is used on pipes for high or low pressures and temperatures. Example:

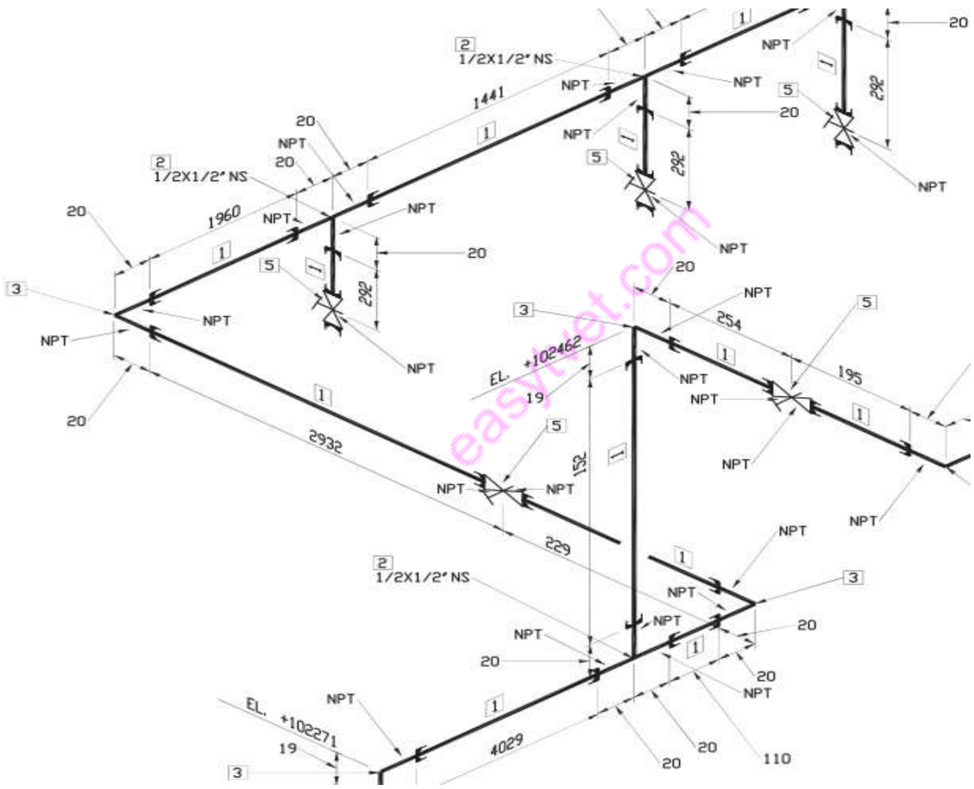
NPS	OD	Schedule #	Wall Thickness	ID
1.000"	1.315"	SCH 40	0.133"	1.049" (approx.)
1.000"	1.315"	SCH 80	0.179"	0.957" (approx.)

All pipes are specified using the NPS and schedule numbers. It is the schedule number that determines the approximate inside diameter

Estimation of Drainage Materials and Costing.

The required materials for the drainage system are estimated from the working plumbing drawing from which quantities are taken and the cost drawn out from the existing market.

Fig 1.5: An example of a working plumbing drawing



The Quantities are taken and cost estimates are made in the BQ.

Table 6: *A sample BQ for plumbing works*

ITEM	DESCRIPTION	UNIT	QTY.	RATE	AMOUNT
				SHS.	SHS.
(II)	**INTERNAL PLUMBING**				
A	**PP-R PN20 Pipes:**				
(i)	25mm diameter pipe chased in walls/floors and in ducts	LM	20		
(ii)	20mm diameter Ditto	LM	12		
(iii)	15mm diameter Ditto	LM	12		
	Extra-over PP-R pipework for the following:				
B	**Bends/Elbows:**				
(i)	25mm diameter bends	No.	10		
(ii)	20mm diameter Ditto	No.	10		
(iii)	15mm diameter Ditto	No.	10		
C	**Tees:**				
(i)	25mm x 20mm diameter tees	No	10		

(ii)	20mm x 15mm diameter Ditto	No.	20		
D	**Sockets:**				
(i)	25mm diameter Sockets	No.	8		
(ii)	20mm diameter Ditto	No.	10		
(iii)	15mm diameter Ditto	No.	10		
E	**Reducers:**				
(i)	25mm x 20mm diameter Reducers	No.	10		
(ii)	20mm x 15mm diameter Ditto	No.	20		
F	**Valves;**				
(i)	25mm diameter PPRC gate valves	No.	3		
(ii)	20mm diameter Ditto	No.	3		
(iii)	15mm diameter Ditto	No.	3		
G	**Pipe clips;**				
(i)	25mm diameter Pipe Clips	No.	5		
(ii)	20mm diameter Ditto	No.	4		

(iii)	15mm diameter Ditto	No.	4		
H	**End Caps;**				
(i)	25mm diameter End Caps	No.	4		
(ii)	20mm diameter Ditto	No.	4		
(iii)	15mm diameter Ditto	No.	4		
I	**Male/Female Screwed adapter;**				
(i)	25mm diameter screwed adapters	No.	10		
	TOTAL CARRIED FORWARD TO NEXT PAGE				

3.2.1.4 Learning Activities

Practical activities

Quantify all the materials and supplies that are required to maintain the drainage system in your institution administration block.

Materials Required

- Pen
- Notebook

- Pencil
- Drawing sheets

3.2.1.5 Self-Assessment

1. What are Pipe Schedules?

The schedule number on pipe products relates to the thickness of the wall on the pipe: as the number increases, the thicker the wall thickness becomes.

Which are the three general grouping/categories of polyethylene (PE) pipes.

i. **High-density**
ii. **Medium-density PE**
iii. **Low-density**

3. Which are the five disadvantages of plastic pipes?
4. Which are the three types of plastic pipes?
5. Drainage system installations?

3.2.1.6 Tools, Equipment, Supplies and Materials

- Pen
- Notebook
- Pencil
- Drawing sheets

3.2.1.7 References

BS 6465: Sanitary installations; Part 7: 7984 Code of practice for scale of provision, selection and installation of sanitary appliances

BS 5503: Specification for vitreous china washdown WC pans with horizontal outlet; Part 1: 7977 Connecting dimensions; Part 2: 7977 Materials, quality, performance and dimensions, other than connecting dimensions

BS 5504: Specification for wall hung WC pans; Part 7: 7977 Wall hung WC pan with close coupled cistern. Connecting dimensions; Part 2: 1977 Wall hung WC pan with independent water supply. Connecting dimensions; Part 3: 7977 Wall hung WC pan. Materials, quality and functional dimensions other than connecting dimensions.

BS 1125: 1973 WC flushing cisterns (including dual flush cisterns and flush pipes)

3.2.1.8 Model answers

1. **What are Pipe Schedules?**

The schedule number on pipe products relates to the thickness of the wall on the pipe: as the number increases, the thicker the wall thickness becomes.

2. **Which are the three general grouping/categories of polyethylene (PE) pipes**.
    i. **High-density**
    ii. **Medium-density PE**
    iii. **Low-density**
3. **Which are the five disadvantages of plastic pipes?**
    - poor structural stability (requiring additional support)
    - susceptibility of some types of plastics to physical changes resulting from exposure to sunlight
    - low resistance to solvents, poor fire resistance
    - lowered pressure ratings at elevated temperatures
    - Production of toxic gases which are released upon combustion of some types of plastic pipe.
4. **Which are the three types of plastic pipes used in drainage?**

- Polyvinyl Chloride (PVC) Pipe
- Polypropylene (PP) Pipe
- Polyethylene (PE) Pipe

5. **What are four factors considered when selecting components and materials for pipes and fittings in drainage system installations?**

- Total installed cost.
- Corrosion resistance of the pipe and fittings
- Physical strength of the pipe and fittings.
- Fire resistance of the pipe and fittings.

3.2.3 Learning Outcome 3: Use drainage tools and equipment

3.2.3.1 Introduction to the learning outcome

This learning outcome enlightens the trainee on the tools and equipment used installing drainage systems as it involves in construction industry.

3.2.3.2 Performance Standard

1. Personal Protective Equipment is used in line with occupational safety and health requirements
2. Drainage tools and equipment are identified based on the requirements of the job.
3. Drainage tools and equipment are used based on manufacturer's instructions.
4. Drainage tools and equipment are cared for and maintained based on manufacturer's manual and workplace place policy.
5. Drainage tools and equipment are stored based on work place policies.

3.2.3.3 Information Sheet

Definitions of terms

- **Tool i**s anything which is held by hand and assists a person to do manual work.
- **Pipe** is a long hollow cylinder used chiefly to convey fluid.

- **Material** is the matter from which a thing is made.
- **Equipment** is a power tool usually run by a motor
- **Maintenance** is the act of keeping tools and equipment in good working condition
- **Repair** is the process of fixing tool or equipment to make it serviceable again.

Tools and Equipment Required

These tools can be broadly classified into two;

- Hand tools -Hand tools include anything from axes to hammers, and screwdrivers to wrenches
- Power Tools require a non-human power source to function properly e.g. External (electricity, compressed air, etc.) or Internal (battery pack, internal combustion engine, etc.).

The tools are further classified into six classes based on the job requirement namely;

1. **Measuring tools**
2. **Cutting tools**
3. **Boring tools**
4. **Driving tools**
5. **Testing tools**
6. **holding tools**

Measuring tools- are tools used to obtain dimensions or angles in a piece of work. They are marked in different units.

Table Table 7: Measuring tools

Name	Uses	Image
inside caliper	used to measure the internal size of a pipe.	
Outside caliper	used to measure the external size of a pipe.	
Steel square	primarily used to measure the accuracy of right angle (90˚ degrees) tried on any surface so as to check its straightness or correspondence to an adjoining surface.	
Pull-Push Rule	Use to measure lengths of pipe for installation	

Cutting tools- is any tool that is used to remove material from the workpiece by means of shear deformation. Cutting may be accomplished by single-point or multipoint tools. Single-point tools are used in turning, shaping, plaining and similar operations, and remove material by means of one cutting edge. Milling and drilling tools are often multipoint tools. Grinding tools are also multipoint tools.

Table 8: Cutting tools

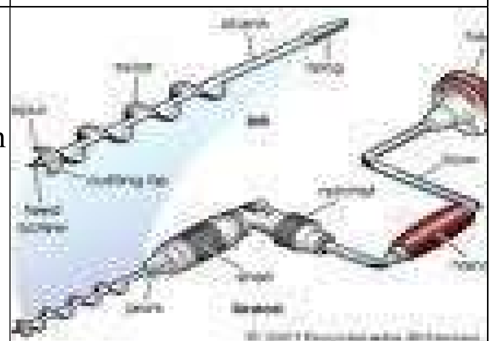
Name	Uses	Image
pipe cutter	used for cutting metallic pipes and tube	

pipe threader	Used for threading pipes.	 
Pipe reamer	used for cleaning the inside portion of the pipe and tube to remove the burst and chips.	
Hacksaw	Used for cutting metal or plastic pipe.	

Boring tools-boring is the process of enlarging a hole that has already been drilled by means of a single-point cutting tool, for example as in boring a cannon barrel. Boring is used to achieve greater accuracy of the diameter of a hole, and can be used to cut a tapered hole.

Table 9: Boring tools

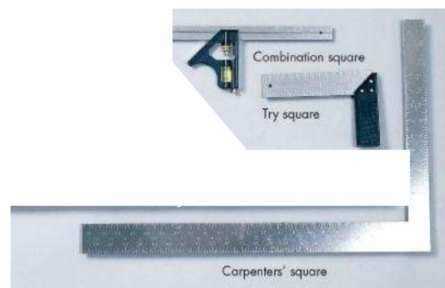
Name	Uses	Image

Electrical drill	Is a power tool that rotates a replaced drill bit to make a hole in wood, plastic or metal. Alternately, a screw driver tip can be installed to turn screw.	
hand drill	Used with drills or bits found around the tang. The tang is the end of the bit of which is held in the brace.	
cold chisel	a tool made from hexagon or octagon-shaped steel and is commonly called cold chisel steel. Its convenient size is for handling. One end is shaped for cutting operations.	

Testing tools-used in finding out the perpendicularity or levelness of the finished work.

Table 10: Testing tools

Name	Uses	Image

Plumb bob or plummet	Used for testing and surveying to position a point on the ground that is not readily visible. Plumb bob is a weight with a pointed tip at the bottom that is suspended from a string and used as a vertical reference line.	
Squares	Used for laying out angles. It has two edges that form a 90□ angle.	
Levels	A level has tubes partially filled with colored liquid leaving a trapped air bubble. Used to level a pipe	

1. **Driving tools-**driving tools help hand tools and power tools work together, especially important for the variety of drilling tasks that get done in woodworking.

Table 11:Driving tools

Name	Uses	Image
crow bar	Consists of a metal bar with a single curved end and flattened points, often with a small fissure on one or both ends for removing nails.	
screw driver	Used to insert and tighten, or to loosen and removescrew. The screw driver comprises a head or tip which engages with a screw, a mechanism to apply torque by rotating the tip, and some way to position and support screw driver **types:** triple square, spanner head, torque, tri wing, obertson, hex allen, torx, pozidive, crosshead, flat	

2. **Holding tools-**tool for holding firmly any material that has to be cut.

Table 12: holding tools

Name	Uses	Image
Adjustable spanner/wrench	used to loosen and tighten a nut or bolt. It has a jaw of adjustable-size, which allows different sizes of nut and bolt.	
basin wrench	Is a specialized tool which allows one to reach tight spot under sink and basin. The jaw of the basin wrench can not only be adjusted to accommodate nuts of different sizes, but it can also be flipped over the opposite side to keep it turning without removing the wrench	

clamp	used to grip and hold an object firmly such as wood, paper, plastic and some metals for a short period time.	
Pipe wrench	Is an adjustable wrench used for turning soft iron pipes fittings with a rounded surface. The design of the adjustable jaw allows it to rock in the frame such that any forward pressure on the handle tends to pull the jaw tight together	
bench vise	Used for holding or clamping a work piece to allow work to be performed on it which uses an anchor. Bench vise or vice has one fixed jaw and another, parallel, jaw which is moved towards or away from the fixed jaw by the screw	

Safety when using tools and Equipment

- Always wear eye protection.
- Wear the right safety equipment for the job.
- Use tools that are the right size & right type for your job.
- Follow the correct procedure for using every tool.
- Keep your cutting tools sharp and in good condition.

- Don't work with oily or greasy hands.
- Make sure each tool type has a separate compartment in ther toolbox, as this will help to stop them coming into contact with others that could damage them

Maintenance of tools

Here are some of the practices that enhance the lifespan of the tools and same time limit injuries to the user:

- Hand and power tools with adjustable parts need lubrication
- For storage maintain their optimum level of performance and to help fight rust development
- Only use tools in proper working order.
- Regular repair of broken parts.
- Clean your tools after use.

PPE used when carrying drainage systems installations

Face protection

Goggles and face protection must be used when workers are at risk from flying particles, liquid chemicals, acids or caustic liquids and chemical gases. Various goggles for face protection must meet certain design criteria for safety.

Foot Protection

Safety shoes with impact protection are used in work areas where heavy objects or tools could be accidentally dropped on the feet. Safety shoes with puncture protection are required when working around nails, wire tacks, scrap metals and other objects that could fierce the feet.

Hand Protection

Gloves are required to protect the hands of workers from cuts, scrapes, punctures, burns, chemical absorption, and exhaust temperatures. It is crucial that the type of glove being used is the right one for the job.

Hearing Protection

Appropriate **ear muffs or ear plugs** must be made available as a last resort if it is not possible to make the workplace less noisy. The requirement is a small part of the occupational noise exposure standard which requires employers to ensure that workers are exposed to less than 90 decibels of noise over an 8 hour period.

Respirators

Appropriate **respirators** must be worn as a last

resort if it is not possible to ventilate the work area properly.

Overalls

Overalls are a type of safety clothing made of tough cotton, denim or linen and usually used as protective clothing while working. It is a loose fitting pair of pants with supporting cross-straps, or a full or half sleeve shirt that is worn over regular shirts, vests and trousers to protect them from heat, cold, splashes, sparks, flames and flying debris etc. in the workplace.

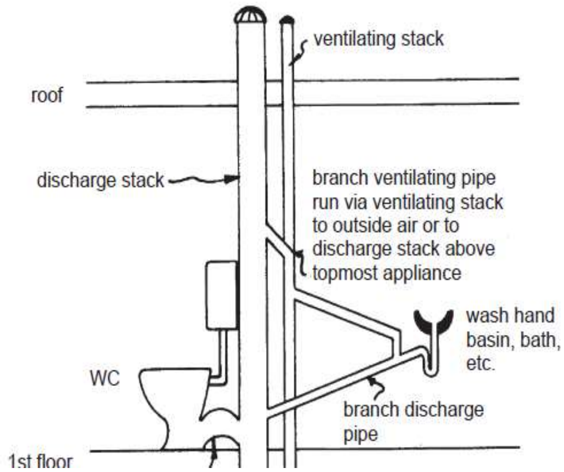
3.2.3.4 Learning Activities

Practical activities

You are required to undertake the following activities in from your institution's drainage system

a) Identify all the tools you would use to install the drainage system below
b) Highlight the use of each tool named in (a) above
c) Give 10 maintenance practices for the tools named above

Figure 164: Drainage system installation



Materials Required

- Pen
- Pencil
- Straight edge
- Notebook

3.2.3.5 Self-Assessment

Which safety measures would you observe when using plumbing tools and equipment?

1. Which four cutting tools would you use when installing a metallic pipe?
2. Which four PPE's would you use when installing an elevated steel tank?
3. Draw a pipe wrench.

5. Which are the two broad classes of tools?

3.2.3.6 Tools, Equipment, Supplies and Materials

- Pen
- Pencil
- Straight edge
- Notebook

3.2.3.7 References

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3.2.3.8 Model Answers

1. **Which safety measures would you observe when using plumbing tools and equipment?**

    - Always wear eye protection.
    - Wear the right safety equipment for the job.
    - Use tools that are the right size & right type for your job.
    - Follow the correct procedure for using every tool.
    - Keep your cutting tools sharp and in good condition.
    - Don't work with oily or greasy hands.

2. Which four cutting tools would you use when installing a metallic pipe?

    - pipe cutter
    - pipe threader
    - Pipe reamer
    - Hacksaw

3. Which four PPE's would you use when installing an elevated steel tank?

- Gloves
- Boots
- Googles
- Overall

4. Draw a pipe wrench.

5. Which are the two broad classes of tools?
   - Power tools
   - Hand tools.

3.2.4 Learning Outcome 4: Set out Drainage systems

3.2.4.1 Introduction to the learning outcome

This learning outcome will help the trainee gain the competencies required in setting out drainage systems as it involves in construction industry.

3.2.4.2 Performance Standard

1. Measurements are transferred to the ground based on working drawings
2. Joint positions are identified based on the working drawings and standards
3. Invert levels are taken based on the gradient.

3.2.4.3 Information Sheet

Definitions of terms

i. **Levelling** is a process of determining the height of one level relative to another. It is used in surveying to establish the elevation of a point relative to a datum, or to establish a point at a given elevation relative to a datum
ii. **Datum:-** Datum plane is an arbitrarily assumed level surface or line with reference to which level of other line or surface are calculated.
iii. **Reduced level (RL**):- Height or depth of a point above or below the assumed datum is called reduced level.
iv. **Bench mark (BM)**:- B.M. is a fixed reference point of known elevation. It may be of the following types.
v. **Boning Rods and Sight Rails** are tools as old as time but still important and extremely useful when setting out paving and drainage projects
vi. **Reduced level (RL**) is the height or depth of a point above or below the assumed datum.

Setting out the fall

The method used to ensure the pipe is laid to the correct gradient will depend upon the length of drainage run, and for short sections a gradient board, or incidence board, is used.
The gradient board is a plank of wood cut to the required gradient of a drain and used in conjunction with a spirit level. If a drain run is to have a fall of 1 in 40 the drop in depth over 1m would be (1 ÷ 40 = 0.025m) 25mm.

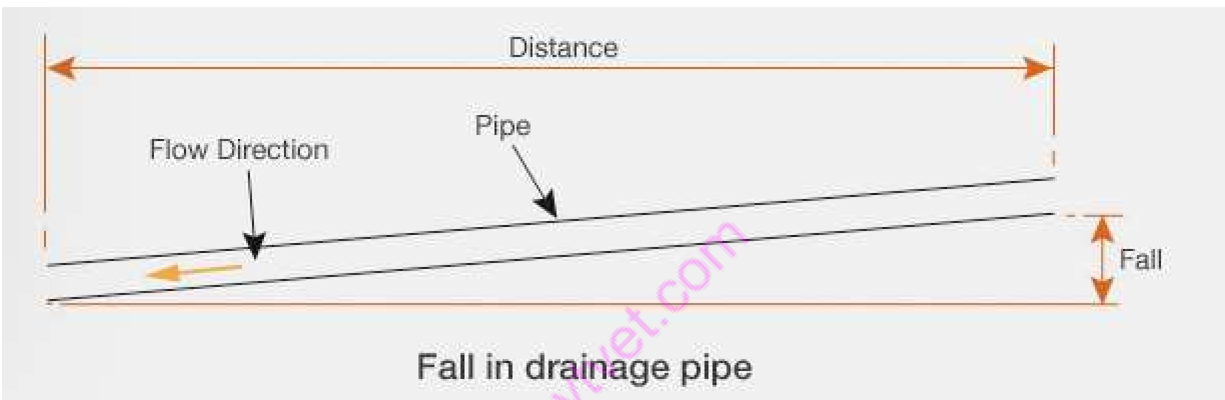
So, to make a simple gradient board, take a straight plank 1m long and cut it at an angle. Where a long drainage run is to be installed the method used to determine the fall should be carried out using sight rails and traveler (also called a boning rod). First the site rails are positioned at either end of a drainage run at different heights, the difference being that of the required gradient.
This process is done by a site surveyor, using a site level, or by using a water level to give an accurate transference of levels between each end of the drainage run. Then the trench is excavated to the required fall or backfilled as necessary. Two operatives are then used; one sighting his eye between

the site rails and instructing his partner to raise or lower the traveler by lifting or lowering the boning rod as necessary

Determining Drainage Levels

Falls

The fall in a pipe may be defined as the vertical amount by which the pipe drops over a distance. The distance can be between sections of pipe or between manholes. The diagram below shows pipe fall and distance.



FALL = GRADIENT X DISTANCE

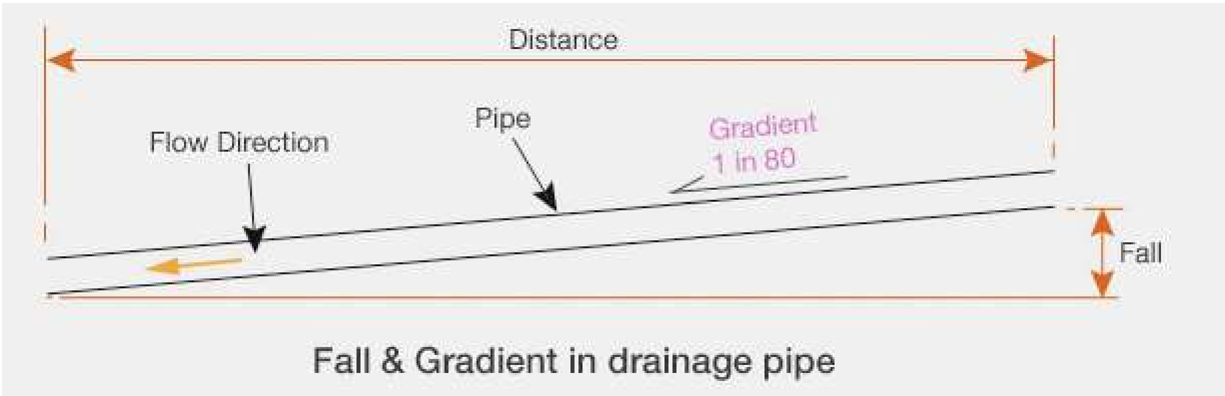
For example, calculate the fall in a 50 metre section of foul water pipe work if the gradient is to be 1 in 80.

A gradient of 1 in 80 is converted to a number instead of a ratio – 1 / 80 = 0.0125

Fall = 0.0125 x 50

Fall = 0.625 metres or 625mm.

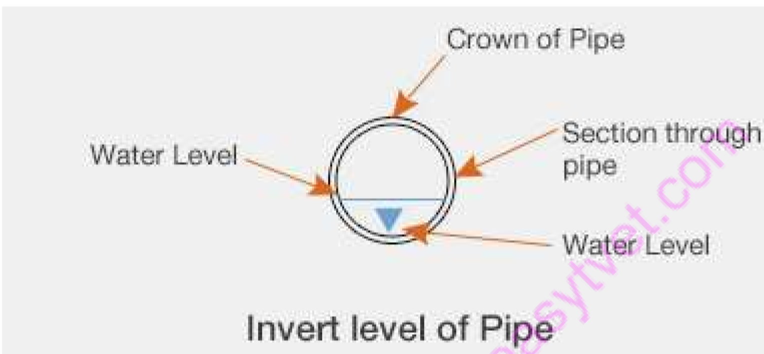
The previous diagram may be completed by adding a pipe gradient.



Fall & Gradient in drainage pipe

Invert Levels

The invert level of a pipe is the level taken from the bottom of the inside of the pipe as shown below.



Invert level of Pipe

The level at the crown of the pipe = the invert level + internal diameter of the pipe + pipe wall thickness. It may be necessary to use this in calculations when level measurements are taken from the crown of a pipe.

Table 13: Determining levels

Pipe Diameter (mm)	Recommended Fall
100	1 in 40
150	1 in 60
225	1 in 90

Drainage Calculations

To calculate the difference in levels of the two ends of a drain a simple formula is used which is:

Length of run ÷ Gradient

The gradient is always expressed as "1 in a given distance", e.g.:

1:40 means a drop of 1mm in 40mm or 1 metre in 40 metres

1:60 means a drop of 1mm in 60mm or 1 metre in 60 metres

Example: If a 100mm drain pipe 70m long is laid to a gradient of 1:40 what would be the difference in level of the two ends.

Length of Run

Gradient

= 70

40

= 1.75m or 1,750mm

Boning Rods

Boning rods - These are T-shaped and of a uniform height. They can be easily manufactured by nailing a wooden lath of approximately 80 cm long and 10 cm wide on another lath of approximately 150 cm long and 10 cm wide so that the end result looks like a "T" (figure 5). A simple stand can be manufactured so that the setting out can be done by two instead of three persons if necessary.

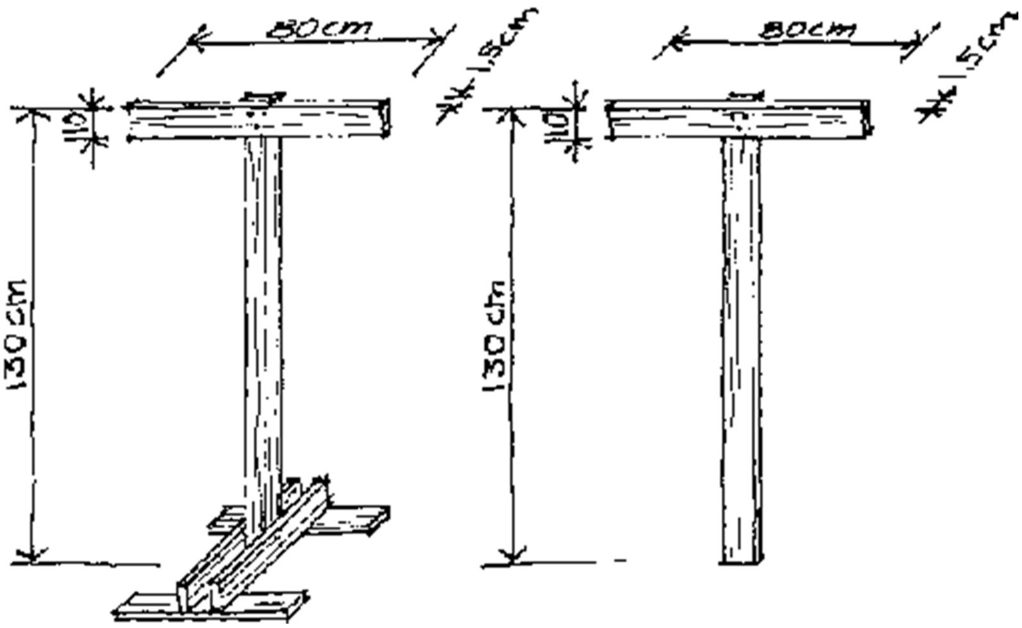
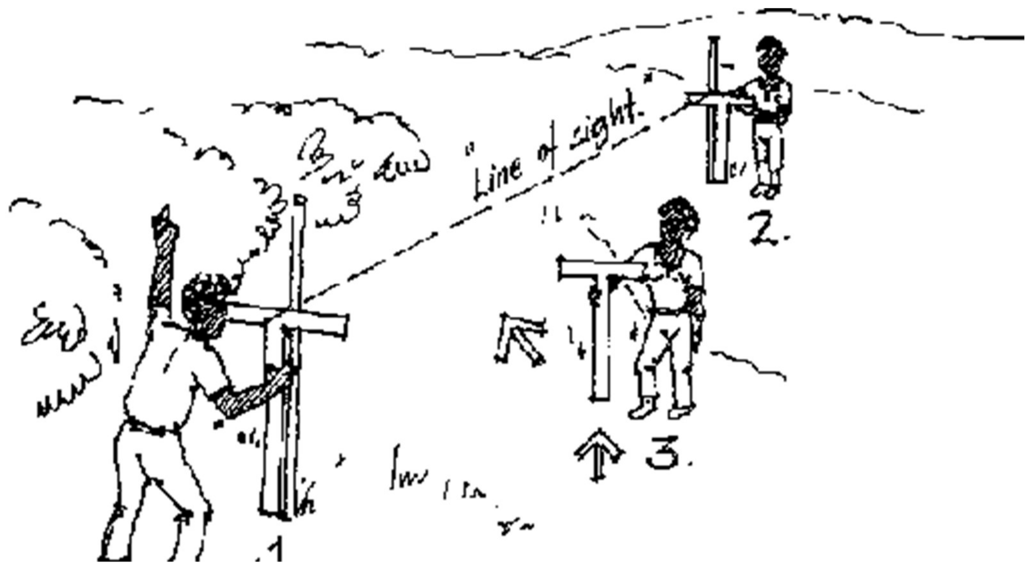


Fig. 5.

Paint the upper lath in a clearly visible colour. Different colours should be used for different boning rods.

When "level pegs" show two levels of the road "boning rods" can be used to establish a "line of sight", which enables you to find additional levels in between or beyond the level pegs. This "line of sight" is established by putting boning rods on top of the level pegs and looking over the top of the boning rods. Figure 6 shows how the new level is found:



This man can see that boning rod 3 is too low. When the man in the middle moves uphill his boning rod will come into the line of sight. He then moves his boning rod up (or down) until the top is at the correct height. The bottom of the boning rod is then at the required new level.

Note that this method should not be used to set out new alignments in hilly terrain, but only to find additional points between level pegs! Setting out in hilly terrain by an inexperienced person can cause excessive and unnecessary earthworks.

Use of boning rods

Boning rods are used to set out horizontal lines or lines with a constant slope. In particular they are used for setting out canal excavation works, but also for roads and dyke construction.

To be able to set out horizontal lines or lines with a constant slope, the elevation (or height) of two points on the line (preferably the starting and end points) must be known.

Dumpy level

A dumpy level (also known as a Builder's Level) is an optical instrument used to establish or check points in the same horizontal plane. It is used in archaeological surveying to measure horizontal levels, for example to demonstrate the difference in height at the top and base of a slope such as an excavated pit or a surviving earthwork.

Equipment

The level 'kit' consists of a level head (in box), staff and tripod.

The level head comprises an eyepiece, bulls eye spirit level, three levelling screws and a focus for the telescope lens; the base also incorporates a 360 degree compass.

The 5m staff is in sections. Each ‘block’ represents one centimetre, and each 'E' represents 5 centimetres. The 10 cm sections alternate back and forth and between black and white, and the colour alternates between black and red for each metre.

The tripod is composed of aluminum and plastic, with three extendable/lockable legs and a base plate with screw fitting with which to attach the level head. There is a canvas carrying strap and a belt to secure the legs together.

To set up a TBM: mark an easily identifiable permanent feature nearby – eg. a coloured brick in a wall, or a fence post; a wooden stake may also be used.

Setting up the level

- Find a benchmark location near the spot you want to measure. A benchmark location is a spot that you already know the height of thanks to previous land surveys.

If possible, set up in the centre of the area that you intend to survey, or somewhere that you can see all of the site as well as the back sight/Bench Mark, with the top plate relatively level.

Set your tripod up near the spot you want to measure. Place your tripod on a patch of flat, clear ground that sits between your benchmark location and the spot you want to measure. Then, undo the latches on your tripod's legs and extend each leg out. Adjust the legs until your tripod is completely level, then close each latch.

- Almost all tripods come with a built-in bubble level. You can use this to assess whether or not the tripod is level.
- To measure the area properly, make sure you set up in a spot that's slightly higher than your benchmark location.

Connect your device to the tripod and position it over 2 leveling screws. Screw your dumpy level onto the tripod's base plate, then connect the base plate to the main tripod body. Once the instrument is securely attached, turn the dumpy level's telescope so that it sits parallel with 2 of the device's leveling screws.

- If the dumpy level wobbles when tapped, tighten the leveling screws to better secure the device.

Level the device by adjusting the 2 leveling screws. Look for a traditional bubble level located somewhere on your device. When you find it, grab the 2 leveling screws that are parallel to the device's telescope and twist them in opposite directions. Do this until the bubble sits in the exact center of the level.

Turn your telescope 90 degrees and adjust the third leveling screw. After adjusting your first 2 leveling screws, turn your telescope approximately 90 degrees so that it sits parallel to the device's third leveling screw. Then, adjust this screw until the bubble once again sits in the center of the level

Check your level's calibration by turning it 180 degrees. After making your initial leveling adjustments, return your telescope to its starting position and check that the bubble still sits in the center of the level. If it does, turn the telescope 180 degrees and check the level again. You can focus the device once all 3 positions show the bubble in the center of the level.

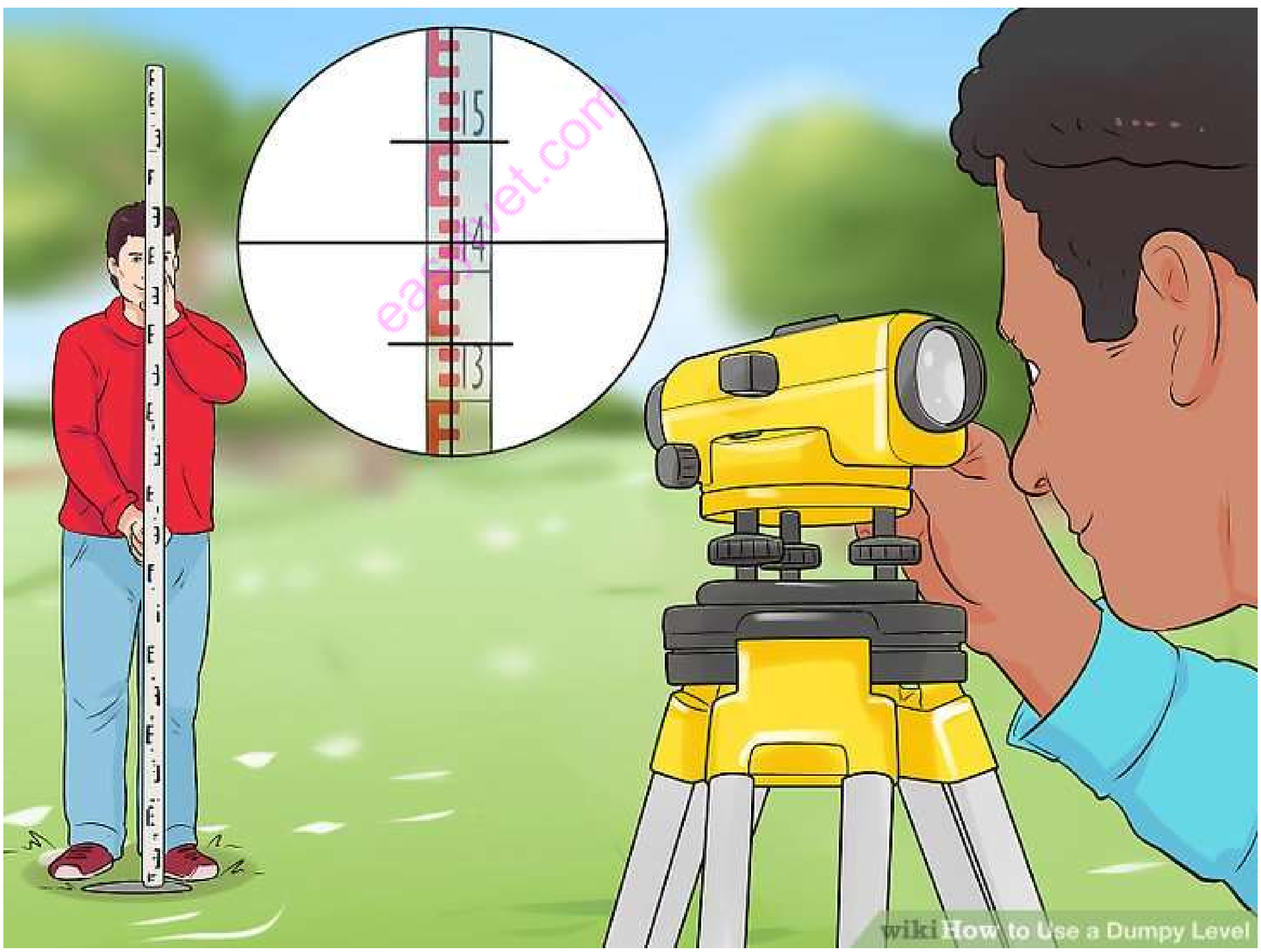
Focusing your level.

- Remove your dumpy level's lens cap.
- Adjust the eyepiece until you can see the device's crosshairs.
- Twist the device's focusing knob until the image is clear.

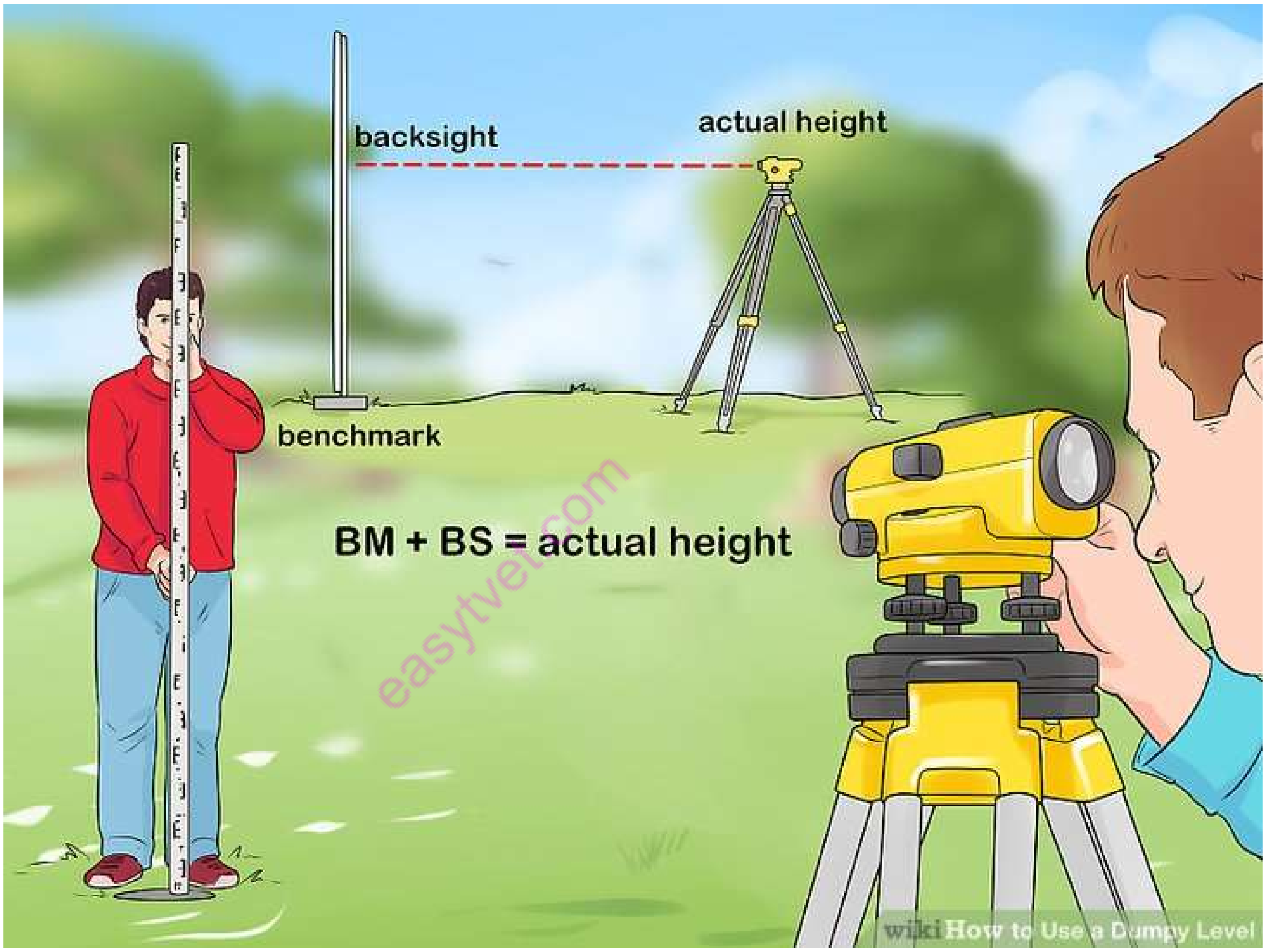
Taking measurements.

1. Position an E staff on top of your benchmark spot.

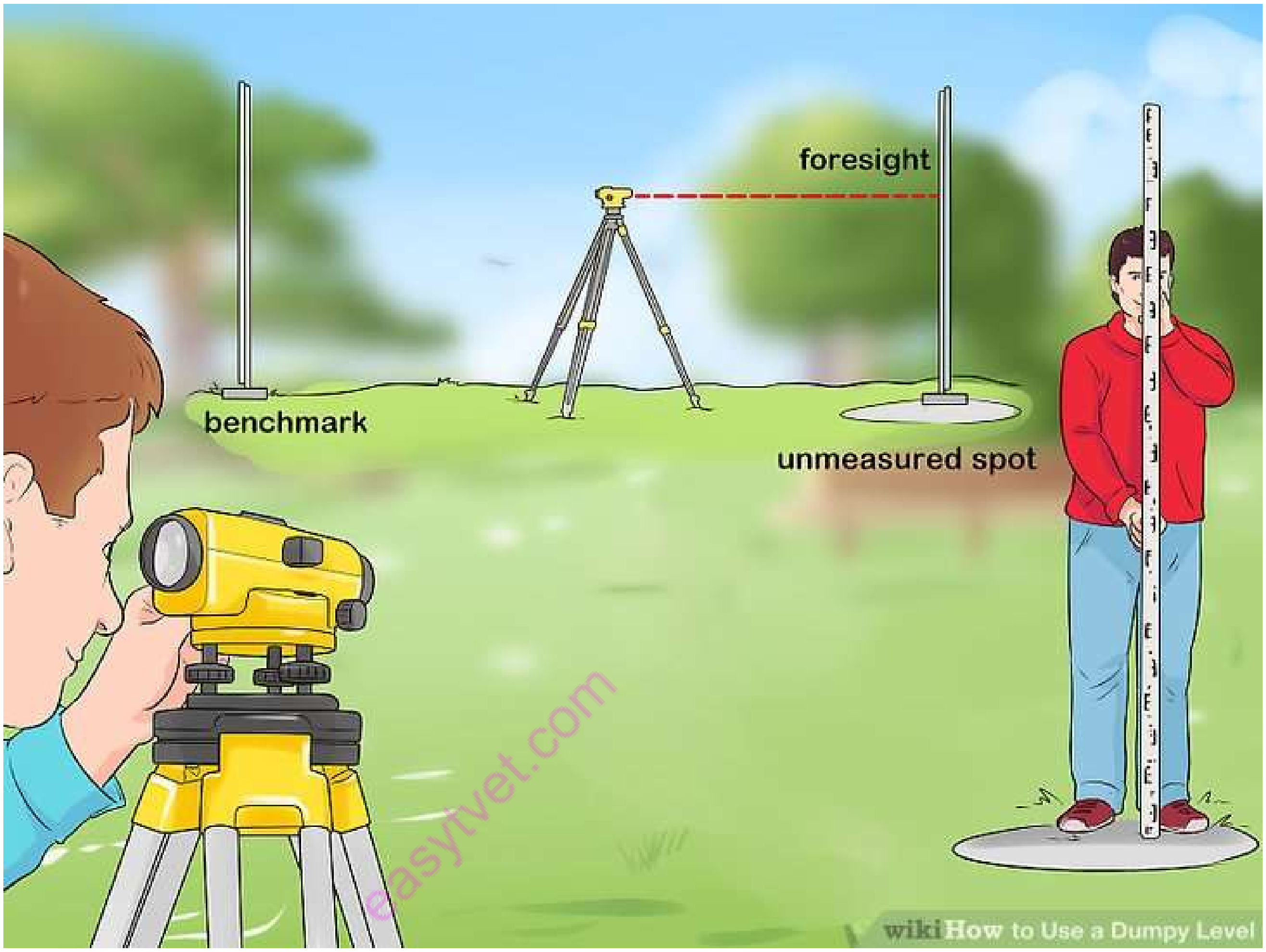
2. Find the height difference between your level and the benchmark spot. Look through your dumpy level's telescope and locate the E staff. Then, record the measurement indicated by your device's center, horizontal crosshair.

- This measurement is known as your backsight.
- Each numbered section of your staff represents 10 cm (3.9 in). Within these sections, every block indicates 1 cm (0.39 in) and every E indicates 5 cm (2.0 in).
- 

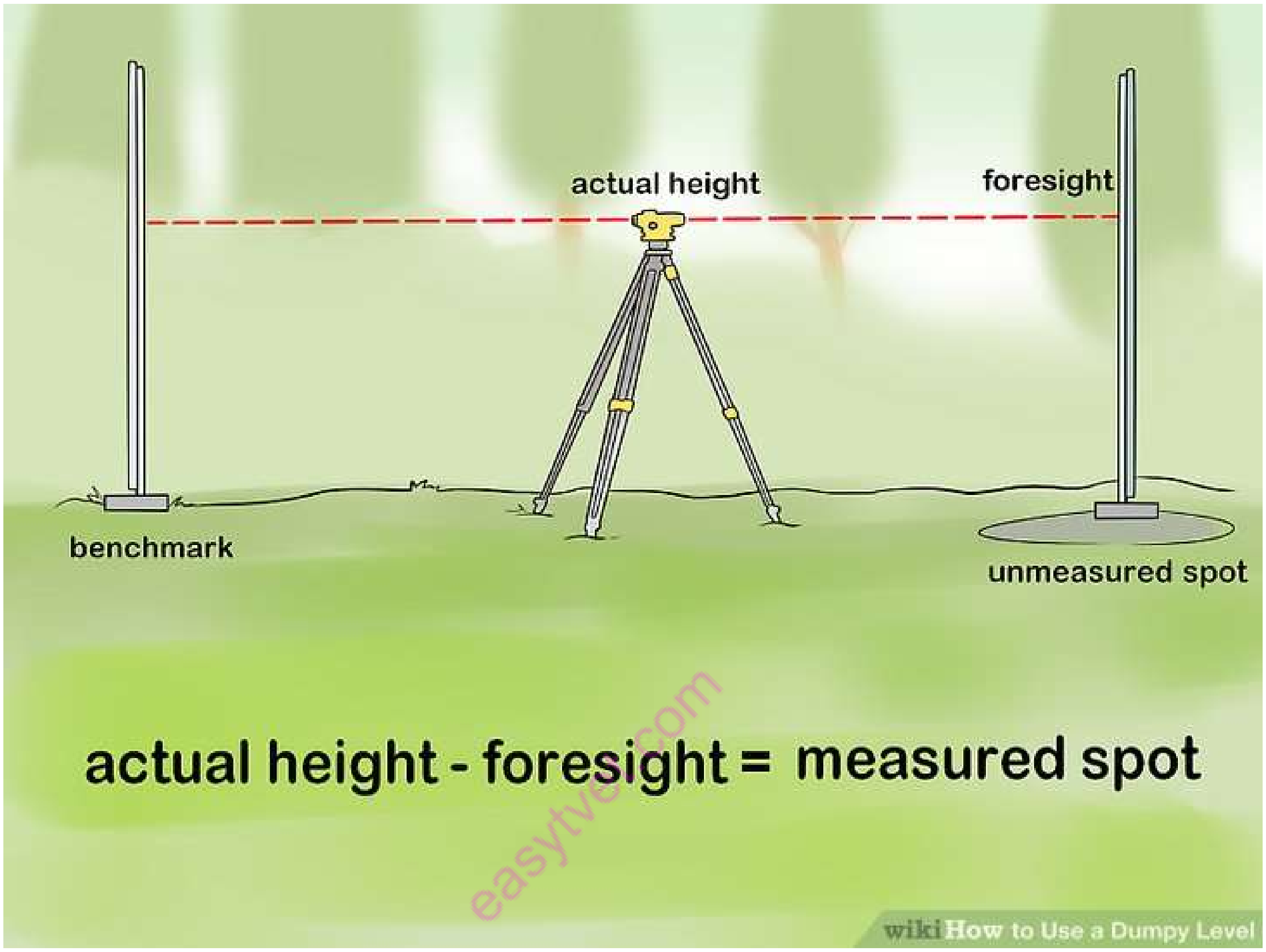
3. Calculate your level's actual height using the benchmark height. Once you have your backsight measurement, add it to your benchmark location's actual height. This will give you the current height of your dumpy level's telescope.

- Record this measurement so you can use it to find the height of your next spot.
- 

4. Find the height difference between your level and the unmeasured spot. Move your E staff so it sits directly on top of the spot you want to measure. Use your device's telescope to find the staff, then record whatever number the device's center, horizontal cross hair sits over



4. Calculate the spot’s actual height using your level’s height. Unlike with your previous calculation, you’ll need to subtract your foresight measurement from your dumpy level’s actual height. This will give you the height of the spot you measured.



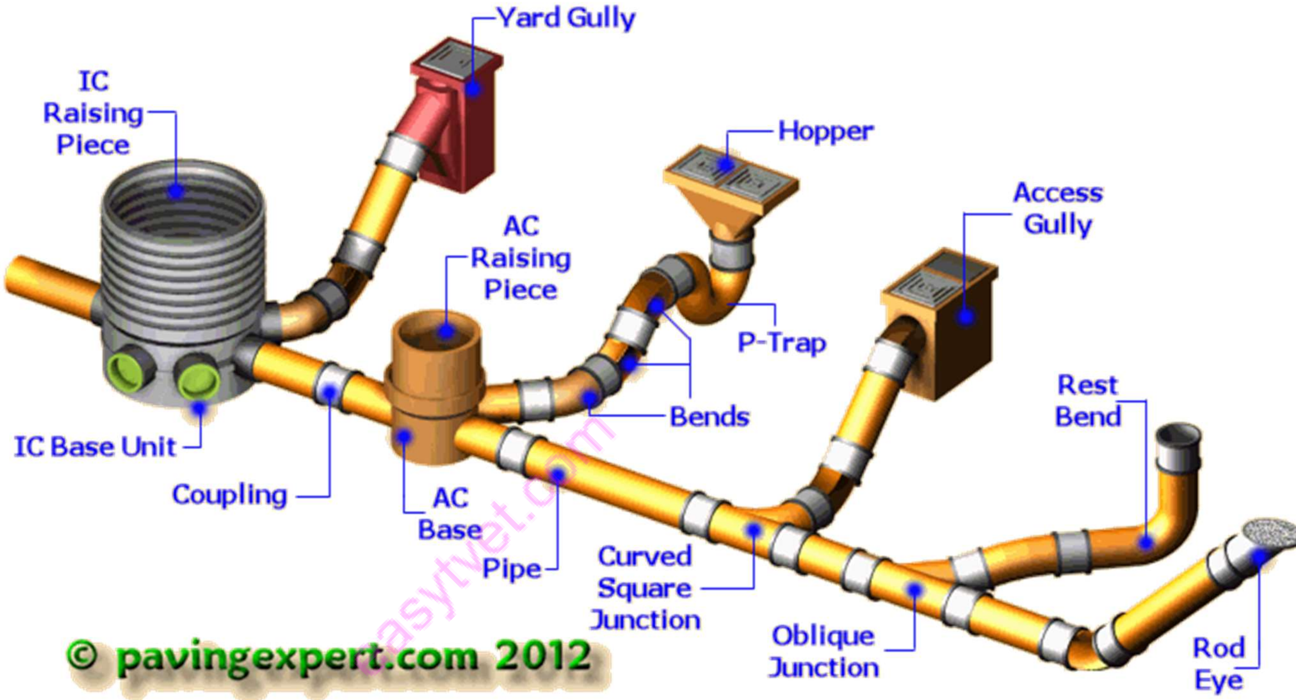
3.2.4.4 Learning Activities

Practical activities

Procedure

1. Assemble all tools and materials required
2. Set out the drainage system at a gradient of 1:40 as shown in the figure below.

Figure 165: Drainage system installation



Materials Required

- Measuring tools
- Levelling equipment's
- Mason trowels
- Mason square
- Spirit level
- Boning rods
- Floats
- Mallet

- Ball hammer
- Masonry chisel
- Pipes

3.2.4.5 Self-Assessment

1. What is the meaning of fall as used in determination of drainage levels?
2. Calculate the fall in a 70 meter section of foul water pipe work if the gradient is to be 1 in 60.
3. State two uses of boning rods.
4. What is a dumpy level used for?
5. What do you understand by the term **'reduced level?'**

3.2.4.6 Tools, Equipment, Supplies and Materials

- Measuring tools
- Levelling equipment's
- Mason trowels
- Mason square
- Spirit level
- Boning rods
- Floats
- Mallet
- Ball hammer
- Masonry chisel

3.2.4.7 References

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3.2.4.8 Model answers.

1. What is the meaning of fall as used in determination of drainage levels?
   The fall in a pipe may be defined as the vertical amount by which the pipe drops over a distance.
2. Calculate the fall in a 70 meter section of foul water pipe work if the gradient is to be 1 in 60.

   Solution
   1 in 60 =1/60
   =0.01667
   Therefore fall =70 meters * 0.01667=1.1667
   Fall =1.1667 meters.

3. State two uses of boning rods.
   - **Are used to set out horizontal lines**
   - **Set out lines with a constant slope**
4. What is a dumpy level used for?
   - **A dumpy level is an optical instrument used to establish or check points in the same horizontal plane**
5. What do you understand by the term **'reduced level?'**

- **Reduced level (RL) is the height or depth of a point above or below the assumed datum.**

3.2.5 Learning Outcome 5: Install above ground drainage system

3.2.5.1. Introduction to the learning outcome

This learning outcome helps the learner to develop competency in installation of all pipework systems that is installed to convey the discharges of sanitary appliances down to the below-ground drainage system and the faults associated with the above ground drainage.

3.2.5.2. Performance Standard

1. Soil and waste water is identified based on the working drawings.
2. Setting out is carried out based on the working drawing.
3. Pipes are laid based on the levels.
4. Housekeeping is conducted based on workplace procedure
5. Safety and health practice are observed based on OSHA.
6. Functionality tests are conducted based on best practices
7. Faults in the system are corrected based on best practice.

3.2.5.3. Information Sheet

Soil and waste pipe systems should be designed to carry away the discharges from sanitary fittings quickly and quietly without the risk of injury to the health of the occupants of the building.

Definitions of terms

- ***Discharge Pipe***- means any pipe which is intended to convey discharges from sanitary fixtures or sanitary appliances and includes a waste pipe, combined waste pipe, branch discharge pipe and discharge stack
- ***Drain*** - pipe normally laid below ground level including fittings and equipment and intended to convey foul water or surface water to an outfall.
- *Drain vent pipe* means any pipe which is intended to permit the movement of air into and out of a drain or sewer
- Waste water-used water which is not contaminated by soil water or trade effluent.

- ***Fixture discharge*** *pipe* - a discharge pipe which is used to convey waste from a single sanitary fixture or sanitary appliance to a branch discharge pipe, a discharge stack or directly to
- the drain
- ***Fixture vent pipe*** - a vent pipe which is connected to a fixture discharge pipe or the sanitary fixture itself
- ***Foul water drainage system* -** drains, joints. and fillings normally laid underground and used specifically for the conveyance of foul water from the plumbing system to an outfall
- ***Gully trap*** - a fitting designed to prevent foul air escaping from the drainage system and used to receive the discharge from waste pipes,
- ***Sanitary appliance*** - an appliance which is intended to be used for sanitation, but which is not a sanitary fixture.
- ***Sanitation*** - the activities of washing and/or excretion carried out in a manner so that adverse effects on health are minimized, with regard to dirt and infection.
- ***Sewe****r* - means a drain which is under the control of or is maintained by, a sewage disposal undertaking.
- ***Soil fixture*** - a sanitary fixture constructed to receive solid and/or liquid excreted human waste. It includes a bedpan disposal unit, slop sink, urinal, water closet pan and bidet.
- ***Vent pipe*** - a pipe which is open to the atmosphere at one end and acts as a pressure limiting device
- ***Waste pipe*** –a pipe which conveys waste water ,either alone or together only with rain water.
- ***Waste water fixture*** - a sanitary fixture used to receive wastes which is not a soil a fixture
- ***Water seal*** - the depth of water which can be retained in a water trap
- ***Water trap*** - a fitting designed to prevent foul air escaping from the plumbing system or foul water drainage system and entering a building

Introduction to Above Ground Drainage

The general perception of drainage systems is to remove human waste from a building with the least disruption and impact on our daily lives as possible. This perception is not completely wrong; however, the other main objective of a drainage system is to prevent foul dour ingress into the built environment and thus prevent the possibility of bacterial infection occurring.

Installation procedures

To ensure that the waste water is collected and discharged out of the building safely, during both the design and installation processes, the following areas need to be considered:

- Pipe sizing
- Ventilation system
- Pipework Materials
- Jointing
- Thermal Movement
- Gradients
- Access Pipework Testing

1. Pipe sizing

Drainage systems have many types of appliances discharging into them. To help the engineer correctly design the drainage system, Discharge Units (DUs) and Drainage Fixture Units (DFUs) have been determined using probability distribution law to take into account the probability of use and discharge of individual appliances. The total number of DUs required when incorporated into a mathematical formula will give an acceptable discharge flow rate that can be applied to a table to determine a suitable pipe size. The total number of DFUs can be applied directly to a table to determine a suitable pipe size.

2. Ventilation system

All drainage pipework systems are full of air until an appliance is discharged; once this occurs, the air within the pipework fluctuates. These pressure fluctuations, if not balanced, can adversely affect the water trap seals; therefore, to limit pressure fluctuations, vent piping is traditionally employed.

3. Pipework Materials

There are a number of metallic and plastic materials that can be used for internal drainage systems. Each type of material has its own advantages and disadvantages. The material used should be appropriate for the drainage system being designed.

Jointing There are a number of ways that drainage pipework can be jointed, ranging from solvent welded connections, push fit, fusion welded and mechanical connections. It is necessary to ensure that the jointing system adopted for the drainage system is suitable for the pipework material and the drainage system, along with the environmental conditions in which the pipework system is being installed.

4. Thermal Movement

All pipework materials will expand and contract with changes in temperature, both from ambient temperature and from the temperature of the waste discharge through the pipework. The co-efficient of linear expansion of differing pipework materials will vary; however, the cumulative effects of thermal movement on an installed system can be considerable.

5. Gradients

Any horizontal collector pipework should be designed and installed to the correct gradient and size to ensure that it is uniform, self-cleansing and efficiently carries away the maximum volume of matter which may be discharged into it. .

6. Access

It is essential that adequate provision is made for the testing and maintenance of the above-ground drainage system. Suitable accessibility via access covers, plugs and caps should be provided to enable all traps, discharge pipes and stacks to be tested, cleaned and cleared of any obstructions as and when necessary.

Access points must be;

- Air- and watertight
- Quick and easy to remove
- Fully accessible to facilitate cleansing.

Access points should be located:

- At the base of all soil and waste stacks above the spill-over level of the highest connection on a branch run, typically 1200mm above finished floor level

- At every change of direction, on vertical stacks and horizontal pipe runs
- At regular intervals on long horizontal runs, typically, - at 15m intervals on pipework up to110mm - at 24m intervals on pipework 160mm and above
- Where more than 1 wc is connected to a branch.
- On all appliances, either via the trap or adjacent to the trap
- On multi-story buildings at each floor level.

Types of pipes

Drainage pipes are required in any area to dispose of waste water from our homes and industrial areas. There are different types of drainage pipes for every purpose***. A pipe that facilitates the transfer of water from one place to another is known as a drainage pipe***.

Corrugated Polyethylene Drainage Pipes

Corrugated drainage pipes are strong, durable and cost-effective solutions for good drainage systems. Moreover, polyethylene is a chemically inert plastic that is highly corrosive and abrasion resistant.

PVC Drainage Pipes

Polyvinyl chloride pipes are widely used in drainage systems, as they are cheap, durable and easy to assemble. PVC pipes account for about 75%, in the waste water mains.

Concrete Drainage Pipes

Concrete pipes need no introduction as they are most commonly used in building material. The local availability, effective cost, strength and durability make it the most commonly used drainage pipes.

Copper pipes

Were widely used for residential water and drainage lines. However, these pipes are being replaced by PVC or plastic, the reason being copper is now quite expensive and tends to rust over a period of time.

Types of appliances.

Sanitary appliances

Sanitary appliances are accessories that are designed to receive foul or waste water and then discharge

It through a system of sanitary pipework or directly to the drainage system where it will be disposed off..

Sanitary appliances are classified into:

a. Soil Appliances
b. Waste appliances

Soil Appliances

Soil appliances receive and dispose human excreta. They include bed pan washer, slop sinks, urinals and water closets.

I. Bed pan washer

These appliances are only found in hospitals, hospices and large hotels. They are used for emptying and Washing bed pans. A bedpan or bed pan is a receptacle used for the toileting of a

Bedridden patient in a health care facility, and is usually made of metal, glass, ceramic, or Plastic. A bedpan can be used for both urinary and fecal discharge.

II. Slop sinks

They are deep sink for filling and emptying scrub pails, washing out mops.

III. Urinals

These are appliances are fixed in buildings. They are designed for use by males. There many types of urinals.

a) Stall urinal

It is made in single units complete with floor channel and have sides provided privacy.

b) Slab urinal

They are built up to any required length but do not generally have the side's pieces except at the ends of the ends of the range.

c) Bowl Urinal

It consists of a wall – mounted bowl with optional separate screens fitted in range.

Wash – down Closets

The content of the pan is washed out by the action of the flushing water, which must be directed all Around the pan by a flushing rim.

The water trap seal is normally 50mm deep.

The trap seal is either an s or p – outlet with a diameter of 100mm (4inch).

A simple rubber push – fit connectors with are available to suit into soil pipe. (Waste pipe)

Squatting Closet

This floor – mounted closet is unlike other closet in that you do not sit on it but squat.

It is usually connected to the high level flushing cistern and directs water the closet**.**

Water closets (WC)

They are designed to receive excreta and to flush it into a drainage system. They are smooth and easily

Cleaned surfaces and be made in one piece one – piece wherever possible, with an integral water trap.

Waste Appliances

They receive water and dispose excreta from general washing purposes or food preparation.

They include; Basins, baths, bidets, drinking fountains, sinks and showers.

Drinking Fountains

They are normally install in factories and mines where heavy peak – time washing of hands is needed And a range of washing basins would not be sufficient.

They are usually manufactured as circular bowls with a central pillar through which several nozzles Spray water into the bowl.

They are fixed away from the walls so that people access water round the bowl.

Wash basin or Lavatory

They are used for hand washing and face washing.

They are available in various sizes but the commonest are between 600mm and 685mm wide and Between 400mm to 560mm deep to the back, with a bowl depth approximately 240mm deep.

Domestic basins are usually made of vitreous china and mostly supported pedestal of the same Material.

Baths

They are used for whole body washing and are usually rectangular or tub shaped, with sizes ranging From 1.68 – 1.83 m long, 0.71m – 0.74m wide and 0.43m – 0.45m deep.

Shower

A Shower can be installed to discharge into a bath or into a ceramic or plastic shower tray inside a Waterproof cubicle.

The shower are used for whole body washing and are hygienic than baths because you are not actually

Immersed in dirty water.

Sinks

They are usually fitted in kitchens and used for general household work, including washing and Preparing food.

Their sizes range from 450mm – 1200mm long, 380 – 600mm wide and 200mm – 300mm deep.

Materials like stainless steel enameled steel and plastic are more popular these days and can be

Manufactured in various shapes.

Types of pipework in above ground drainage.

Flow pattern and air pressure fluctuations when reference is made to pipes conveying discharges from sanitary appliances, two classifications of pipe were formulated with the older discharge systems:

- waste pipes: conveying water bound discharges from sinks, baths, showers, washbasins and bidets;
- soil pipes: conveying human discharges from WCs or urinals.

In modern disposal pipework systems these two classes of pipe are combined in a single system. In pipework design, consideration needs to be given to the development of pressure within the system. This pressure can take two forms: positive compression and negative suction. The strongest effects of pressure arise when the bore of the pipe is completely filled, and this is therefore a condition that should be avoided. Where a near-horizontal pipe has a bore completely filled by the flow the name given to the condition is a hydraulic jump formation.

Above drainage pipework connections

The fluid flow in sanitary pipes moves along like a liquid bullet, compressing and displacing the air in front of it and creating negative pressure (suction) behind. Therefore, when full-bore flow occurs in a vertical pipe the effect is termed a plug formation. The significance of these pressure variations is revealed by examination of their effect on the fixtures provided to sanitary appliances. These fixtures include;

a) **Discharge Pipes**

The primary function of discharge pipes is to convey discharges from appliances to the underground drains and they can be arranged in the three different ways: two-pipe, one-pipe and single-stack systems. An efficient system should satisfy the following requirements;

1. Effective and speedy removal of wastes;
2. Prevention of foul air entering building;

3. Ready access to interior of pipes, including provision of rodding eyes where necessary;
4. Protection against extremes of temperature;
5. Protection against corrosion and erosion of pipes;
6. Restriction of siphonage and avoidance of liability to damage, deposition or obstruction;
7. Obtaining economical and efficient arrangements, which are assisted by compact grouping of sanitary appliances.

b) **Traps**

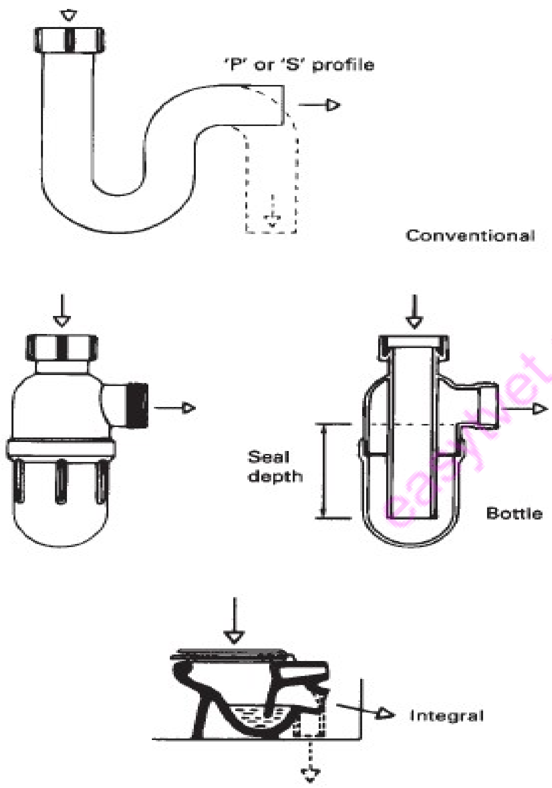
The primary function of the trap is to form a seal against foul air in the pipework system, thus preventing it from entering the building. The trap achieves this by retaining some of the liquid that is discharged by the appliance that it serves. Depths of liquid seal are generally 75 mm, the minimum being 50 mm. The arrangement for liquid retention provides the difference in the style of trap, and a range of types can be listed:

- Conventional;
- Bottle;
- Integral;
- Special.

- **Conventional traps** are formed from a series of bends in the pipe, and allow full pipe bore flow through the trap. This trap requires sufficient space to accommodate the various bends; these are arranged to give a 'P' or 'S' profile, depending on the direction of the trap outlet.
- The **bottle trap** is more compact: it provides excellent access for the clearance of debris, usually by simply unscrewing the base of the trap body. The working principle of the bottle trap does, however, cause disruption to the smoothness of the flow through the trap, which may prevent its use in certain situations for example, where sink grinders are to be used
- The WC has a trap in the body of the appliance itself, which is therefore classified as an **integral trap**. The shape of the outlet and trap provide the distinction between different WC types ('P' and 'S' trap washdown pans).

• **Special traps** provide a particular special function, such as resistance to siphonage action or perhaps the interception of components of a waste discharge such as may be needed for laboratory sinks. Foul air is prevented from entering the premises by the water seal in the trap, and careful thought needs to be given to the preservation of this liquid seal.

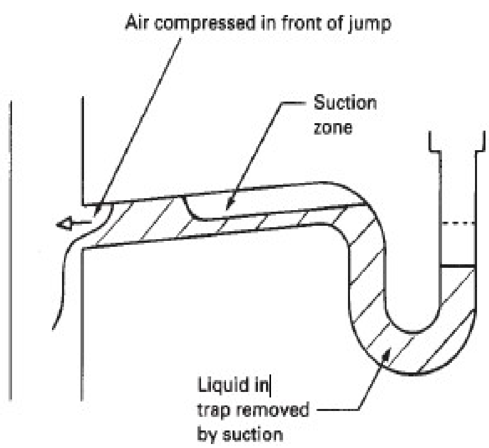
Figure 166: Types of Traps



The occurrence of undesirable discharge flow patterns in the form of hydraulic jump and plug formations may destabilize or even completely destroy the trap seal by the effect of pressure variations created by the flow leading to siphonage of the liquid trap seal resulting from the condition of self-siphonage.

Such an effect may be expected when the incorrect pipe diameter has been selected: for example, a 32 mm bore pipe to a bath rather than the minimum 38 mm needed.

Figure 167: Self siphonage in a waste pipe



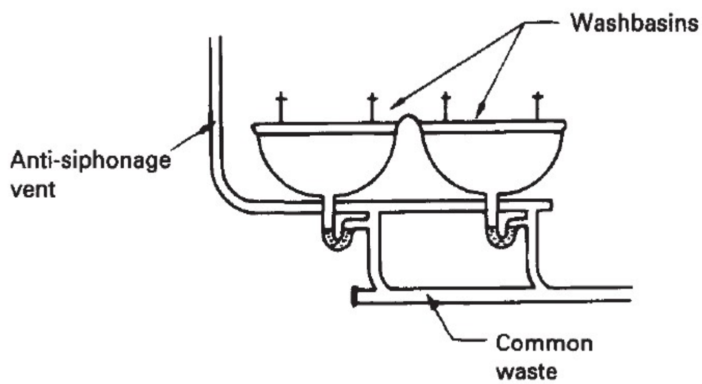
The development of suction is due to flows from other sanitary appliance discharges, which have entered
the vertical stack pipe further up the property. These discharges have caused a plug formation, which rushes past the waste branch to the affected appliance, compressing air in front of it and creating negative pressure in its wake. Such an effect is inducing disturbance of the appliance trap seal, and the description given to the condition is induced siphonage. A number of measures may be taken to avoid the effect of air pressure fluctuations on the liquid retained by traps. Self-siphonage may be avoided by using the correct pipe diameter to suit the appliance served. Induced siphonage may be prevented by using a stack of a diameter that discourages the creation of plug formations.

c) Anti-Siphonage Ventilation

The principle of anti-siphonage ventilation pipework works by connecting a ventilation source to the waste pipe between the stack and the trap, any suction effects can be nullified by drawing in air from the vent connection.

This will of course mean additional cost in the provision of the vent pipework, which sometimes extends through the building into the open air beyond roof level. Once the top floor is reached an alternative route for the ventilation may be by a loop connection to the stack. Special forms of bottle trap can also be used as a source of fresh air entry, to allow one-way movement of air through the trap. The seal against foul air entry to the building is preserved once the air pressure is stabilized by the injection of air. When appliances are connected to a vertical stack, there are often a number of connections to be made on one floor, and bathroom appliances tend to be grouped together.

Figure 168: Anti-siphonage ventilation



d) Waste and Soil Pipework Connections

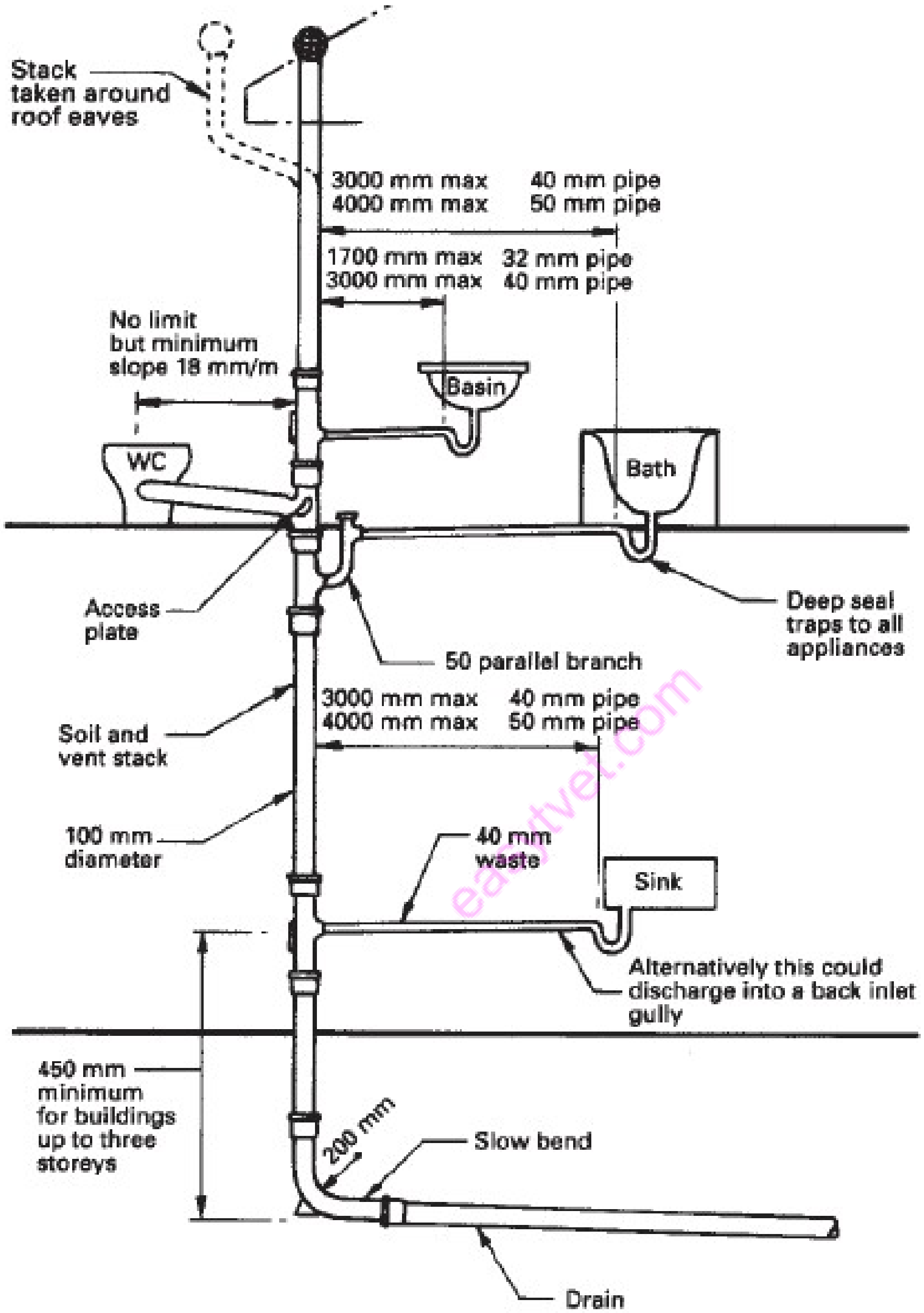
From the variety of different pipework arrangements possible for the collection of discharges from sanitary appliances, there are three major classifications:

- Single-stack system
- One-pipe system
- Two-pipe system.

i. Single stack

Single stack is a solution employed extensively in domestic housing, and a typical layout. The stack in this arrangement may be located inside or outside the external wall of the property, and terminates above roof eaves level with a cage or perforated cover. At this point the stack acts as a means of ventilating the below-ground drainage system, which commences at the base of the stack. Current Building Regulations require the discharge from the waste pipe to enter the gully below grating level but above the water retained by the gully. Other features of the single-stack system are deep seal traps on waste pipes (75 mm minimum seal) and restrictions on the length of waste and soil pipe connections to the stack.

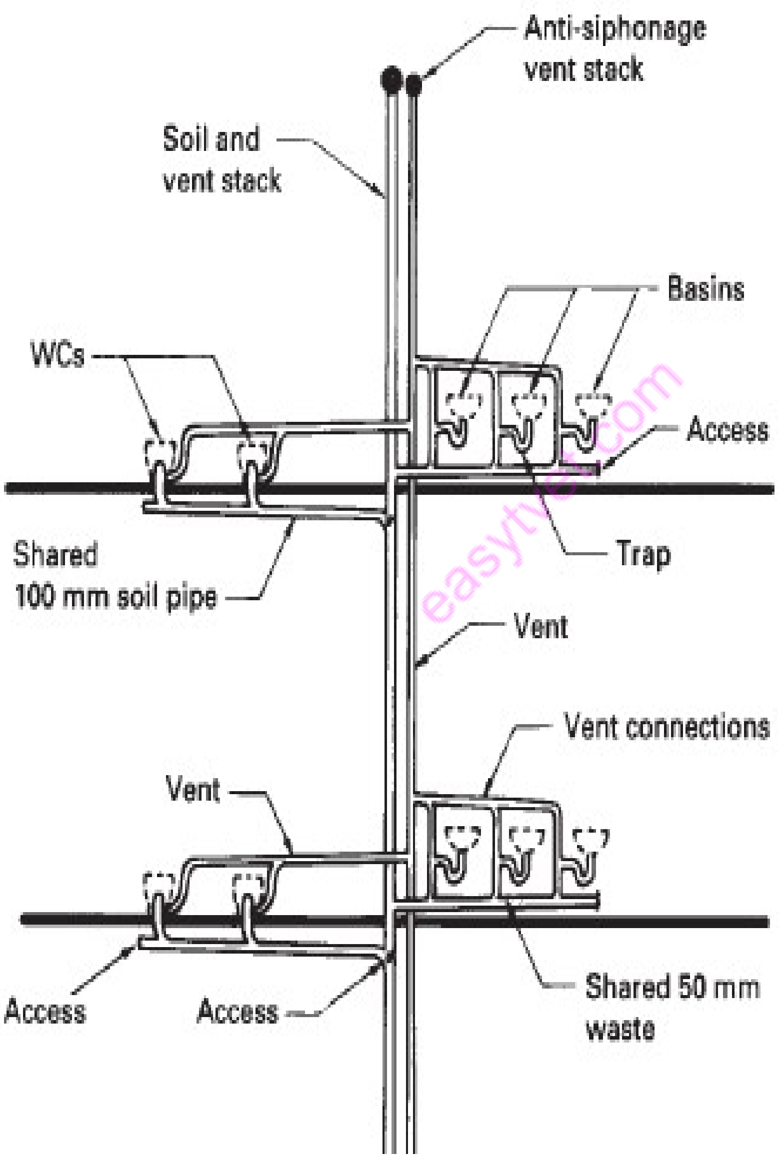
Figure 169: Single-stack disposal installation



ii. The one-pipe system

By contrast, is a fully ventilated arrangement Note the ant siphonage connections throughout. It is often said that the relatively large discharge from the WC is most influential in the development of air pressure fluctuations in the disposal installation, despite the fact that it is only a momentary discharge.

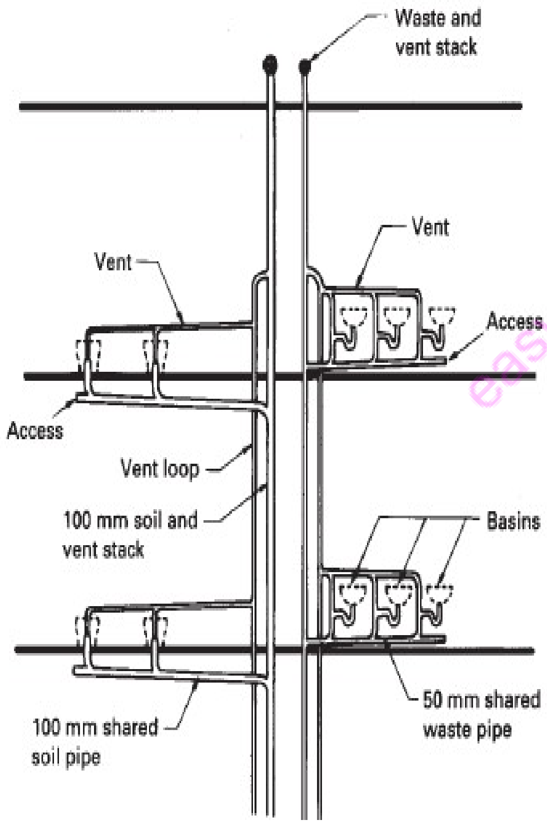
Figure 170: One-pipe disposal installation



iii. The two-pipe system

Separates the WC discharge by using two collecting stacks: a soil stack for collection of the discharges from the we, and a waste stack for collection of the water-bound waste discharges from the other appliances. Selection of one of the disposal arrangements in preference to another is usually based on a number of criteria, of which the proposed layout of the appliances on each floor and the distance of the
appliances to the stack are probably the most influential. Provided that careful design is employed and appliances are grouped around the stack, the economical single-stack system may be chosen for high-rise as well as low-rise structures.

Figure 171: Two-pipe disposal installation



Where the cumulative effect of discharges is such that siphonage effects could develop, and this is particularly the case for multi-story buildings, a one-pipe or two-pipe system may be preferable.

Tests for Above Drainage Systems

After the pipework has been installed it should be tested. The three main methods of testing for pipework soundness are:

- Water Tests.
- Air Tests.
- Smoke Tests.

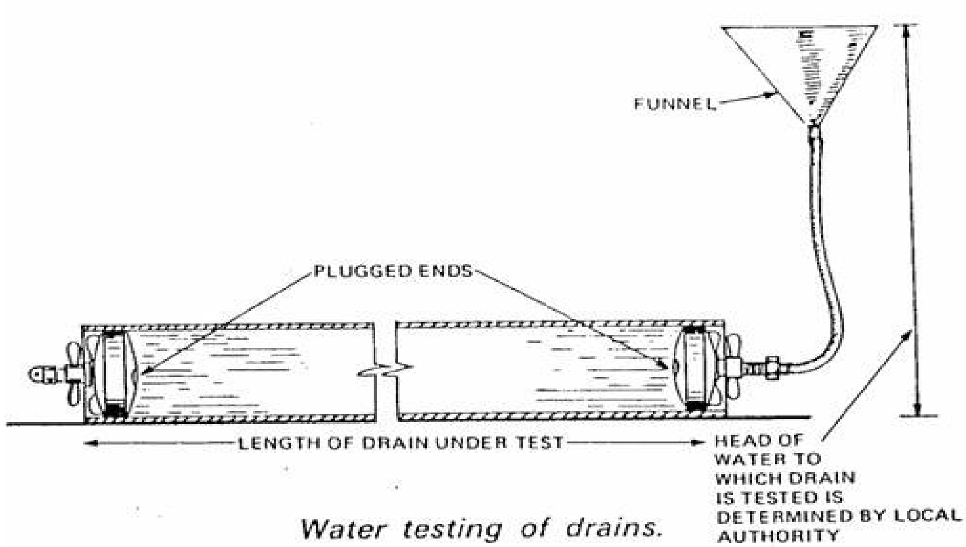
If any leak occurs, the defective pipe or joint should be rectified and once again tested.

Water Tests

- The stack should be filled with water, to give a test pressure equal to 1.5m of water above the soffit of the drain at the high end, but not more than 4m head of water above the soffit of the drain at the low end. Steeply grade drains should be tested in stages, so that the head of water at the lower end does not exceed 4m.
- The pipeline should be allowed to stand for two hours and topped up with water.
- After two hours the loss of water from the pipeline should be measured by noting the quantity of water needed to maintain the test head for 30 minutes. The fall of water needed in the vessel or stand pipe may be due to one or more of the following:

  - Absorption by pipes or joints;
  - Trapped Air;
  - Sweating of pipes and joints;
  - Leakage from defective pipes or joints;
  - Leakage from stoppers.

Figure 172: Water test



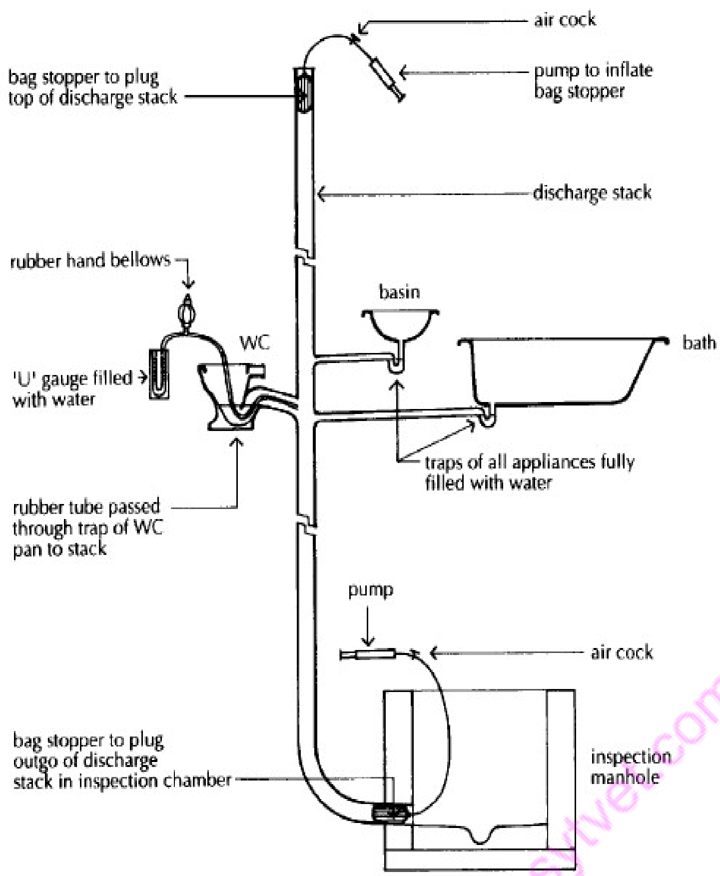
Water testing of drains.

Air Tests

An air test is usually applied if there is insufficient water available for testing, or if there is difficulty in its disposal on completion of the test. Air tests are usually pressurized to 100mm for 10 to 15 minutes, during which time the pressure drop on the gauge must not be more than 25mm.

An advantage with air testing is that all parts of the drain are subjected to the same pressure, unlike water testing where the lower end is at a higher pressure than the inlet. A tee piece with three valves is connected to a manometer (U-gauge), hand pump and a hose. The hose is passed through the seal of a Gulley Trap. With Valves A and C open and Valve B closed, air is pumped into the system. The air pressure is checked periodically by opening Valve B. When the test pressure is reached, Valve A is closed and Valve B is opened. The air pressure is now recorded on the U-Gauge. If the system is sound the difference in levels in the manometer will be retained. Should there be a leak the levels will return to zero.

Figure 173: Air Test



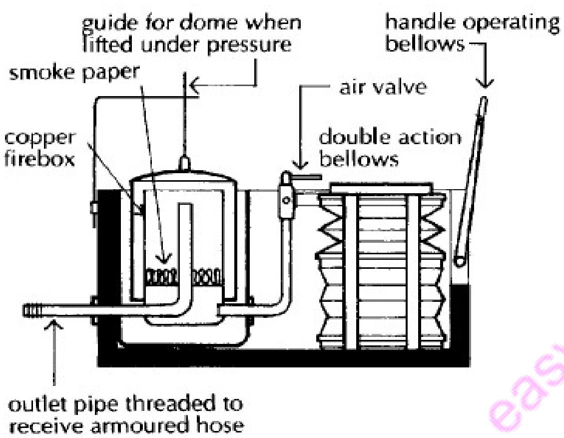
Smoke Tests

The smoke test is used both for testing the soundness of the system and for tracing a suspected leak. It can be used equally well for the testing of above ground soil, waste and vent pipes. All water seals must be charged with water and all branch drains and vents must be sealed except one. Smoke is then pumped into the system through a test plug which is fitted in the lowest point of the drain or stack.

The highest vent is left open until smoke begins to escape. At this point the vent is then sealed and pumping continues until sufficient pressure is built up inside the smoke machine to raise the dome approximately 50mm. Pumping now ceases and the system remains under test for 5 minutes. If the dome remains in the elevated position the system is sound. Should the dome fall or fail to rise a leak is indicated. Pumping is continued while the system is checked for smoke leakage.

This test should not be used on plastic systems, because of the detrimental action between the smoke and some types of plastic.

Figure 174: Smoke testing machine



Plumbing Faults in Drainage Systems and Corrections

Plumbing problems can spring up anytime in systems. Some of the issues are minor and can be fixed without any professional assistance. However, there are problems that only an expert plumber can resolve satisfactorily. Following are some of the common the plumbing defects that can arise in water storage and pumping systems after installation:

1. **Low water pressure**

Poor water pressure is generally caused by blocked joints and elbows. It can be corrected through repair and replacement of the affected joint

2. **Clogged pipes**

When a sticky or hard substance such as a stone or other foreign body passes through pipes it causes obstruction or partially closing the valves and pipes. There are many techniques used to clear the drain and sinks Using an appropriate chemical can fix the minor obstruction. However, chemicals are not always safe.

3. Leaky pipes

Can be caused by pipe joint damage, excessive water pressure, cracked pipes and incorrect pipe laying. This leaking water dampens the walls, making them look ugly and dirty. Damp or wet walls cause unpleasant earthy odor and mold growth. Fix pipe leakages using a shark bite, rubber and metal clamp or by sealing it with an Epoxy seal.

4. Air locks

It occurs in plumbing systems when pockets of air in a pipe trap the water in the pipe, not allowing the water to flow freely through the pipe. This problem usually occurs in hot water pipes, since the water pressure from the hot water tank won't force the air blockage out of the way.

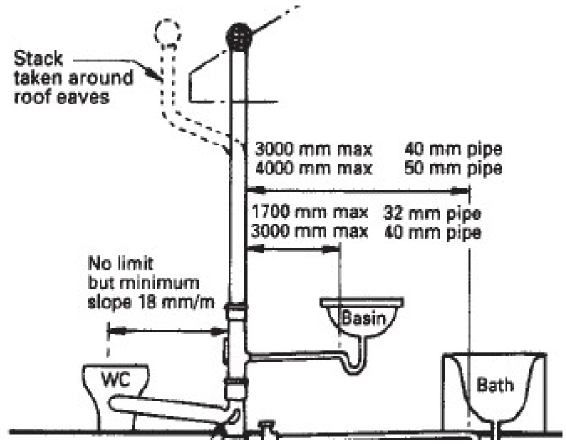
3.2.5.4. Learning Activities

Practical activities

Procedure;

1. Assemble all tools and materials required
2. Install the above ground drainage stack as shown below.
3. Carry out a water test for the system installed.
4. Correct the faults that arise after testing the system

Figure 175: Above ground drainage installation



Materials Required

- Measuring tools
- Levelling equipment's
- Mason trowels
- Mason square
- Spirit level
- Boning rods
- Floats
- Mallet
- Ball hammer
- Masonry chisel

3.2.5.5. Self-Assessment

1. What are the four types of traps?
2. What are the six primary requirements of an efficient system?
3. What are the three pipework arrangements for the collection of discharges from sanitary appliances?
4. Explain the working of an anti-siphon age ventilation trap.
5. What are the two classifications of pipe conveyance for sanitary appliances giving examples?

3.2.5.6. Tools, Equipment, Supplies and Materials

- Measuring tools
- Levelling equipment's
- Mason trowels
- Mason square
- Spirit level
- Boning rods
- Floats
- Mallet
- Ball hammer
- Masonry chisel

3.2.5.7. References

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3.2.5.8. Model answers.

1. What are the four types of traps?
    - Conventional
    - Bottle
    - Integral
    - Special.

2. What are the six primary requirements of an efficient system?
    - Effective and speedy removal of wastes;
    - Prevention of foul air entering building;
    - Ready access to interior of pipes, including provision of rodding eyes where necessary;
    - Protection against extremes of temperature;
    - Protection against corrosion and erosion of pipes;
    - Restriction of siphonage and avoidance of liability to damage, deposition or obstruction;
    - Obtaining economical and efficient arrangements, which are assisted by compact grouping of sanitary appliances.
3. What are the three pipework arrangements for the collection of discharges from sanitary appliances?
    - Single-stack system
    - One-pipe system
    - Two-pipe system.
4. Explain the working of an anti-siphonage ventilation trap.
    - The principle of anti-siphonage ventilation pipework works by connecting a ventilation source to the waste pipe between the stack and the trap, any suction effects can be nullified by drawing in air from the vent connection. This will of course mean additional cost in the provision of the vent pipework, which sometimes extends through the building into the open air beyond roof level. Once the top floor is reached an alternative route for the ventilation may be by a loop connection to the stack. What are the two classifications of pipe conveyance for sanitary appliances giving examples?
    - waste pipes: conveying water bound discharges from sinks, baths, showers,

washbasins and bidets

- soil pipes: conveying human discharges from WCs or urinals.

3.2.6 Learning Outcome 6: Install below ground drainage system

3.2.6.1. Introduction to the learning outcome

This learning outcome outlines on the different processes, activities and equipment involved when undertaking installation for drainage systems below the ground surface and the tests are applied to a newly constructed underground drainage system to ensure correct work free from defects.

3.2.6.2. Performance Standard

1. Excavation is carried out based on the layout.
2. Pipeline base is stabilized based on drawings.
3. Pipes are laid based on the levels
4. Pipe work is protected based on specifications
5. Inspection chambers, man holes and traps are constructed according to specifications.
6. Housekeeping is conducted based on workplace procedure
7. Functionality tests are conducted based on best practices
8. Faults in drainage system are corrected based on best practice.
9. Backfilling and making-good is carried out based on best practice.
10. Safety and health practices is observed according to OSHA and NEMA.
11. Above ground signage is placed based on best practice.

3.2.6.3. Information Sheet

The efficient disposal of foul and surface water from a building is of great importance to public health and is an essential part in building construction. If a drain is unsound and leaks, the escaping water may contaminate the water supply or air.

Definitions of terms

- ***Haunching*** - the concrete which slopes from the top of a drainage pipe down to the bedding
- ***Benching*** - the sloping sides constructed at the base on an inspection chamber to prevent the accumulation of solid deposits
- ***Invert*** -the lowest point of the internal surface of a drain, sewer or channel
- ***Soffit*** -the highest point of the internal surface of a pipeline at any cross-section
- ***Manhole*** – a chamber usually constructed of brick or concrete and designed to expose a section large enough to work in it.
- ***Below ground drainage system*** -This is a system of pipes which conveys surplus water or liquid sewage away from the building in the most speedy and efficient way possible to the sewer without any risk of nuisance or danger to health and safety.

Below Ground Drainage System

When designing any drainage system, one must observe the following principles:

1. Provide adequate access points.
2. Keep pipework as straight as possible between access points and for all bends over 45º and access point should be provided.
3. Ensure all pipework is adequately supported
4. Ensure the pipe is laid to a self-cleansing gradient
5. Ensure the drainage system is well ventilated
6. The whole system must be water tight including inspection chambers.
7. Drains should not be run under buildings, unless this is unavoidable or by so doing it would considerably shorten the route of pipework.
8. The minimum internal diameter of a foul water drain is 100mm.

There are three types of below ground drainage systems:

a) Combined system

In this case, as its name implies, both foul and surface water are discharged into the same sewer This system has the cheapest layout as it requires only one set of pipes, and during heavy rainfall both house drains and sewers are thoroughly flushed out.

Sewers are public authority drains to which private house drains are connected. This system has often been used in the past where raw sewage was disposed of without treatment, ie. discharged into the sea or a water course. There is a further disadvantage: in storms and periods of very heavy rainfall. Flooding and subsequent surcharging of the drains has been known to occur.

b) Separate system

This system requires the use of two sewers one carrying foul water to the treatment works, the other carrying surface water (which requires no treatment) to the nearest water course of river.

It is expensive to install, but from the local authorities' point of view it is the most economical to operate because the volume of sewage to be treated is far smaller than the discharge from a combined system.

The biggest danger is that cross-connections may accidentally be made, i.e. foul water may be connected to a surface water drain.

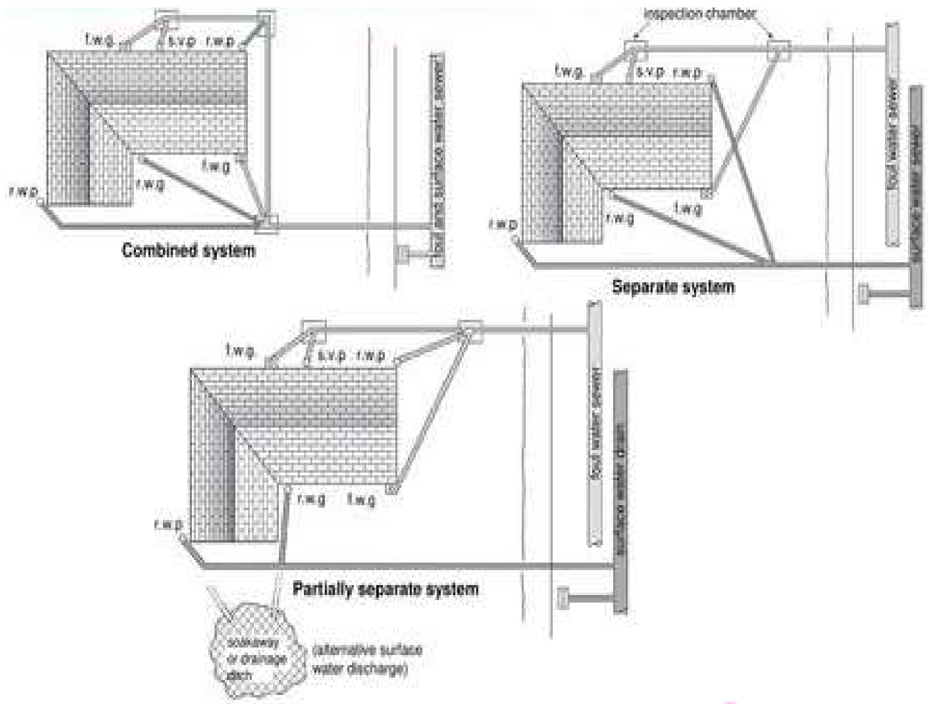
a) **Partially Separate System**

This system probably originated when towns began to grow in size and local authorities found it necessary to try to reduce the loading on the combined system, which in most cases had hitherto been employed. This is something of a compromise between the previously mentioned systems.

It requires two sewers, one carrying water from paved areas and part of the roof, the other carrying foul water and water from the remainder of the roof.

The disadvantage of this system are similar to those of the combined system, but to a lesser degree.

Figure 176: *Below ground drainage systems*



Measuring the gradient or slope while laying pipes.

Pipe slope / gradient: Slope or gradient may be defined as fall divided by the distance.

Gradient = Fall / distance

Sample Calculation of fall: If your drainage pipe length (L) is 15 metres, what is fall (F) required to Attain gradient of 1:60?

Answer:

Slope of 1:60 means the slope will fall 1 meter for 60 meter length of pipe.

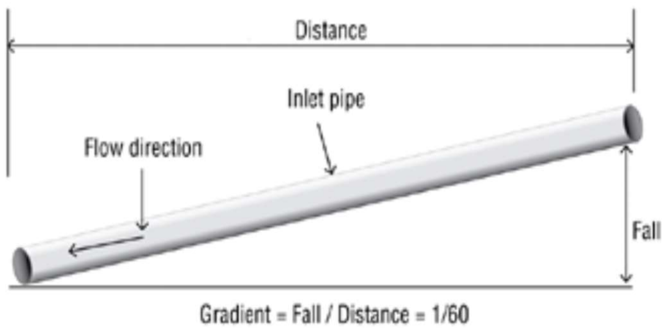
Our Pipe length (L) = 15 meters

So, Fall = Gradient * distance

Fall = 1/ 60 * 15 = 0.25 meters

Fall should be 0.25 m or 25 cm.

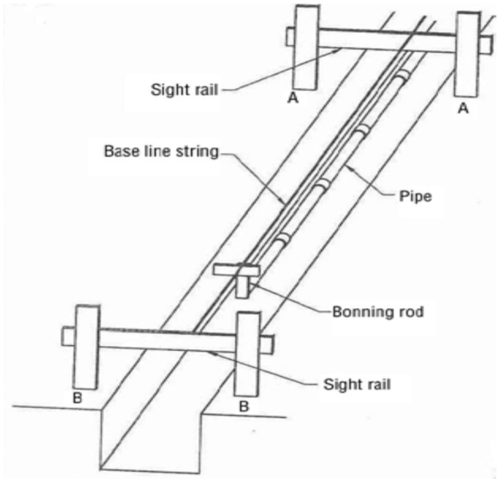
Figure 177: *Fall and gradient in drainage pipe*



Procedure to measure gradient for laying of sewerage pipe:

1. Mark the width of the trench on ground with chalk powder and start excavating to the required depth.
2. Drive two pegs on the side of the trench at the starting point at a distance of 600 mm from the trench mark.
3. Mark the level on both pegs using water level. Fix a sight rail at the mark.
4. Calculate required slope up to the end of the trench
5. Fix two more pegs at the end as done earlier.
6. Mark the level considering the slope required.
7. Fix a sight rail at mark.
8. Tie a string from sight rail at the starting point to the end tightly.
9. Check the bottom level of the trench using a boning rod.

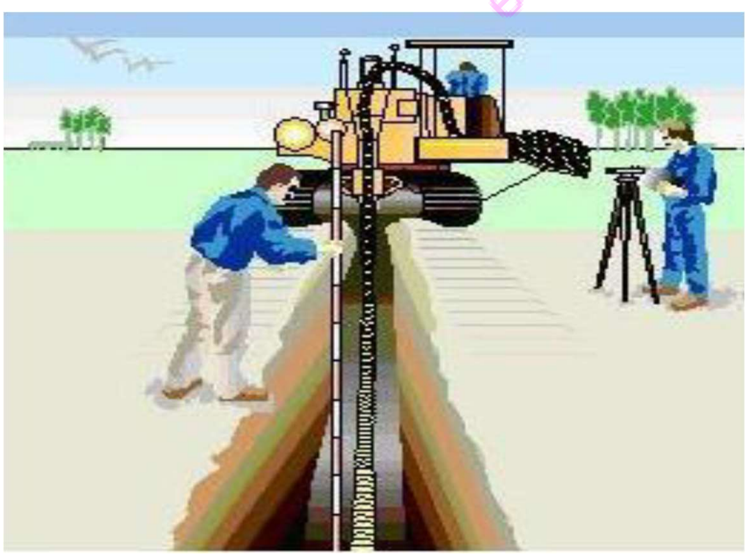
Figure 178: *Measuring gradient*



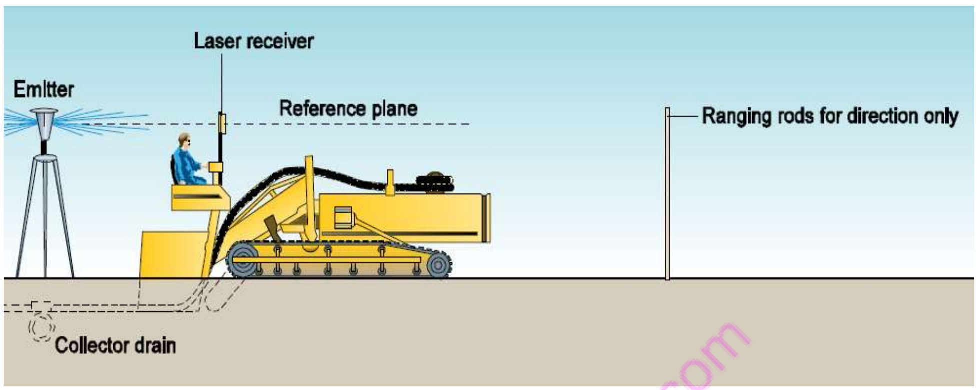
Steps in pipe drain installation

1. Setting out alignments and levels – Involves establishing vertical elevations on the ground surface where the drainage system will be installed. Usually, the difference between the levels of two nearby points is found and the level are reduced.
2. Grade control – Involves ensuring that the required measurements: depth and width and straightness are maintained throughout the excavation process. It is either done manually or by a laser machine

Manual inspection



Automatic grade control by laser



3. Excavating the trenches -it involves making vertical incisions into the ground called trenches to accommodate the pipes. The methods used are either excavation by manual means or mechanically by use of excavators.

An excavator digging up a trench

4. Placing the drain pipes also called pipe laying. It involves laying down drainage pipes on the excavated trenches. It is done by hand or machine.

Pipe laying

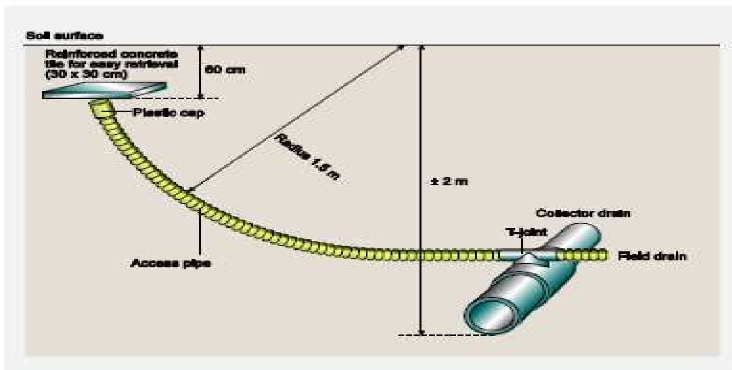
5. Placing the envelopes- done for the protection of the laid pipes either Manually or Mechanically: Synthetic and organic envelopes are prewrapped

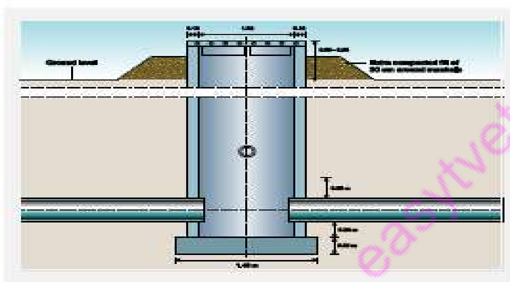
Manual Placing of envelopes

Mechanical placing of envelopes

6. Installation of the junctions/manholes – Manholes are established at identified intervals along the drainage lines for ease of inspection and repair of the drainage system.

Manhole





7.Backfill of the trenches- Involves restoring the surface that was excavated to its original state. Backfill is a three-step operation:

a) Blinding – involves application of a thin layer of soil to cover all the gaping holes
b) Backfill – Involves bringing back the subsoil that was excavated previously
c) Compaction – is the final operation that involves compactors moving on the backfilled portion in order to harden the surface to secure the underground pipes.

Fig 4.0: Mechanical backfilling

8. Site clean-up – it is the final step that involves making sure that the surface is clear from any debris, stones or dirt. The surface should be reinstated to its natural state.

Site clean-up in action

Access to Drains

Although a good drainage system (whether carrying surface water or foul water) should be designed to avoid the possibility of a blockage, circumstances arise, often due to misuse, where this happens. It is therefore very important that adequate provision is made so that obstructions can be cleared with the minimum of trouble.

To enable internal inspection and testing of a drainage system or to provide a route in which the clearance of blockages can be achieved it is essential that sufficient provision is made for the internal access to the drain.

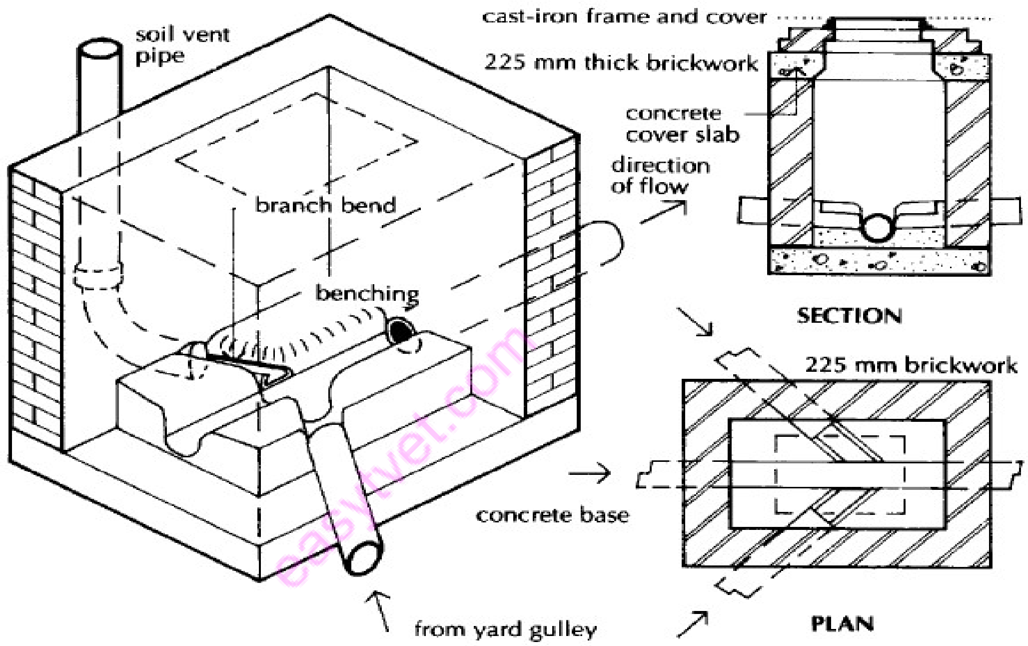
An access point should be provided at the following locations:

- At the highest point or head of the drain.
- At changes of gradient or direction (i.e. bends).
- At junctions or branches.
- At changes in pipe diameter.
- Between long drainage runs.

There are three types of access generally in use:

- **Rodding eyes:** A capped extension on the pipe where access can be gained to a drain or any discharge pipe for the purpose of cleaning with rods or inspection.
- **Access fittings:** A fitting, such as a bend, branch or gully, which has a cover fitted, usually bolted to the fitting, in order to gain access. The cover may be located above ground or at ground level such as in the case of a gully. It may be located below ground; in which case it will need to be incorporated into an inspection chamber or manhole.
- **Inspection chambers and manholes**: A chamber constructed of brick, concrete or plastic and designed to expose a section of open pipe, in the form of a channel at its base. The definition of an inspection chamber or manhole is based on size. If the chamber is large enough to work in it is identified as a manhole, which would certainly be the case in all chambers over 1m deep.

Section view of an inspection chamber



Drainage Installation methods

a) Manual installation

- Labour intensive
- Slow
- No special equipment needed
- Only drain depth < 1.0 m
- Only when water table > drain depth
- More costly

b) Mechanical Installation

- Specialized machines & equipment
- Automatic depth control

- Drain depth above & below watertable
- Only for large-scale projects

c) Combined manual & mechanical installation

- Digging trenches with hydraulic excavators
- Installing drains by hand

Tests for Below Drainage Systems

After the drain has been laid and before backfilling, or pouring concrete or granular material round the pipes, it should be tested. The three main methods of testing underground drains for soundness are:

- Water Tests.
- Air Tests.
- Smoke Tests.

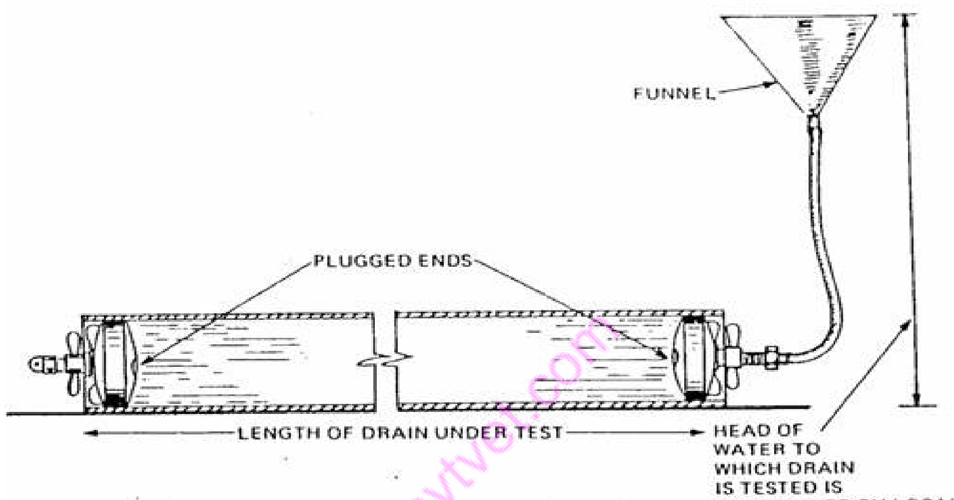
If any leak occurs, the defective pipe or joint should be rectified and the drain again tested. Wherever possible, testing should be carried out between the manholes and short branch drains tested along with the main drainage system. Long branch drains and manholes should be tested separately. The test before backfilling should be carried out as soon as is practicable and the pipe should be supported to prevent any movement of the drain during the test.

1. **Water Tests**

- The drain should be filled with water, to give a test pressure equal to 1.5m of water above the soffit of the drain at the high end, but not more than 4m head of water above the soffit of the drain at the low end. Steeply grade drains should be tested in stages, so that the head of water at the lower end does not exceed 4m.
- The pipeline should be allowed to stand for two hours and topped up with water.
- After two hours the loss of water from the pipeline should be measured by noting the quantity of water needed to maintain the test head for 30 minutes. The fall of water needed in the vessel or stand pipe may be due to one or more of the following:

- Absorption by pipes or joints;
- Trapped Air;
- Sweating of pipes and joints;
- Leakage from defective pipes or joints;
- Leakage from stoppers

Water test



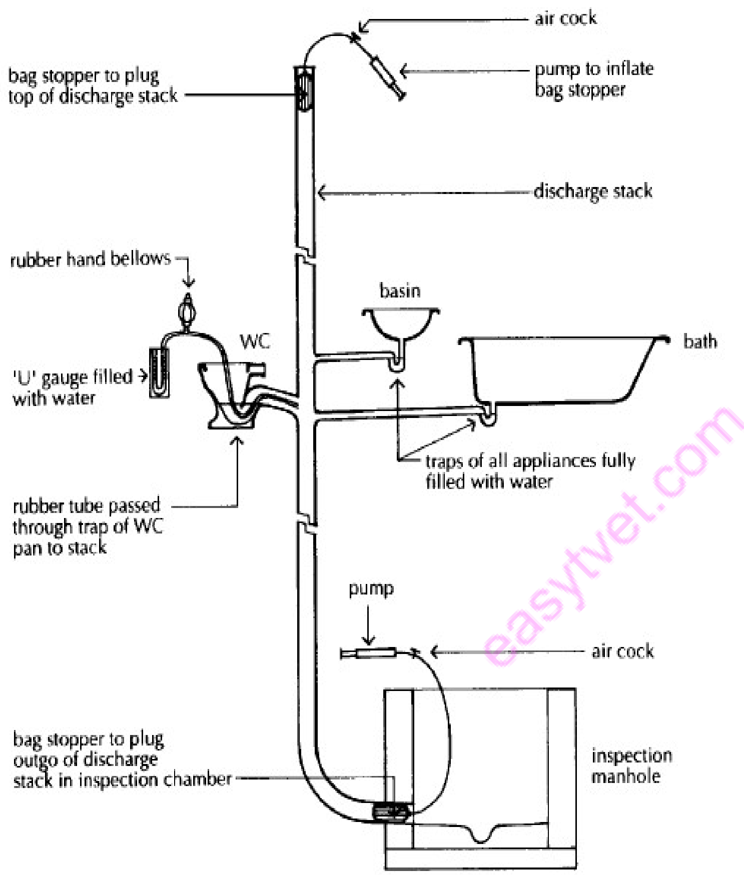
Water testing of drains.

2. **Air Tests**

An air test is usually applied if there is insufficient water available for testing, or if there is difficulty in its disposal on completion of the test. Air tests are usually pressurized to 100mm for 10 to 15 minutes, during which time the pressure drop on the gauge must not be more than 25mm.
An advantage with air testing is that all parts of the drain are subjected to the same pressure, unlike water testing where the lower end is at a higher pressure than the inlet.A tee piece with three valves is connected to a manometer (U-gauge), hand pump and a hose. The hose is passed through the seal of a Gulley Trap. With Valves A and C open and Valve B closed, air is pumped into the system. The air pressure is checked periodically by opening Valve B. When the test pressure is reached, Valve A is closed and Valve B is opened. The air pressure is now recorded on the U-Gauge. If the

system is sound the difference in levels in the manometer will be retained. Should there be a leak the levels will return to zero.

Figure 179: *Air Test*



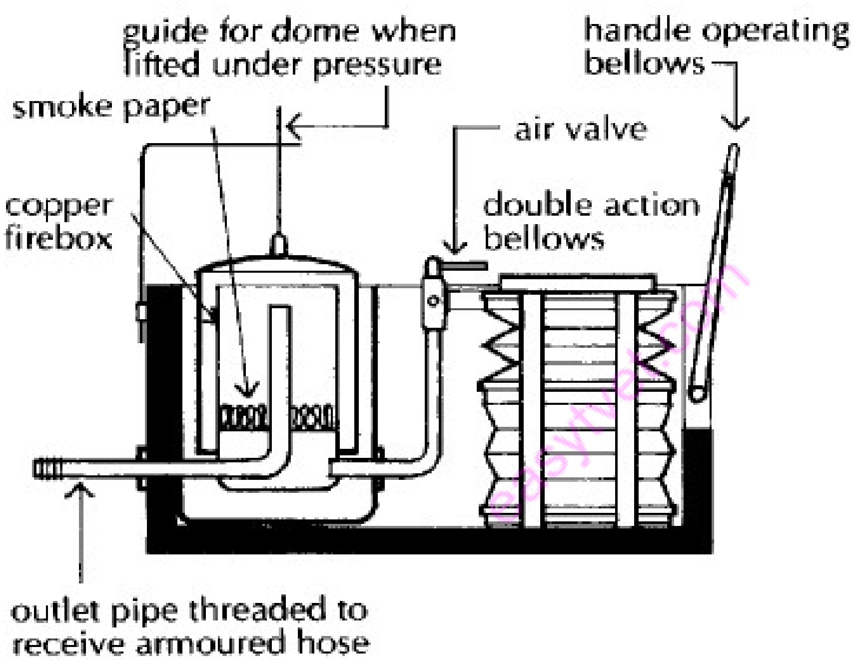
3. Smoke Tests

The smoke test is used both for testing the soundness of the system and for tracing a suspected leak. It can be used equally well for the testing of above ground soil, waste and vent pipes. All water seals must be charged with water and all branch drains and vents must be sealed except one. Smoke is then pumped into the system through a test plug which is fitted in the lowest point of the drain or stack.

The highest vent is left open until smoke begins to escape. At this point the vent is then sealed and pumping continues until sufficient pressure is built up inside the smoke machine to raise the dome approximately 50mm. Pumping now ceases and the system remains under test for 5 minutes. If the dome remains in the elevated position the system is sound. Should the dome fall or fail to rise a leak is indicated. Pumping is continued while the system is checked for smoke leakage.

This test should not be used on plastic systems, because of the detrimental action between the smoke and some types of plastic.

Figure 180: *Smoke testing machine*



Plumbing Faults in Drainage Systems and Corrections

Plumbing problems can spring up anytime in systems. Some of the issues are minor and can be fixed without any professional assistance. However, there are problems that only an expert plumber can resolve satisfactorily. Following are some of the common the plumbing defects that can arise in water storage and pumping systems after installation:

4. Low water pressure

Poor water pressure is generally caused by blocked joints and elbows. It can be corrected through repair and replacement of the affected joint

5. Clogged pipes

When a sticky or hard substance such as a stone or other foreign body passes through pipes it causes obstruction or partially closing the valves and pipes. There are many techniques used to clear the drain and sinks Using an appropriate chemical can fix the minor obstruction. However, chemicals are not always safe.

6. **Leaky pipes**

Can be caused by pipe joint damage, excessive water pressure, cracked pipes and incorrect pipe laying. This leaking water dampens the walls, making them look ugly and dirty. Damp or wet walls cause unpleasant earthy odor and mold growth. Fix pipe leakages using a shark bite, rubber and metal clamp or by sealing it with an Epoxy seal.

7. Air locks

It occurs in plumbing systems when pockets of air in a pipe trap the water in the pipe, not allowing the water to flow freely through the pipe. This problem usually occurs in hot water pipes, since the water pressure from the hot water tank won't force the air blockage out of the way.

Waterproofing to plumbing appliances and fittings can be done using:

- Cement Waterproofing.
- Liquid waterproofing membrane.
- Bituminous Membrane Waterproofing Method.
- Polyurethane Waterproofing
- Teflon tape
- Caulking

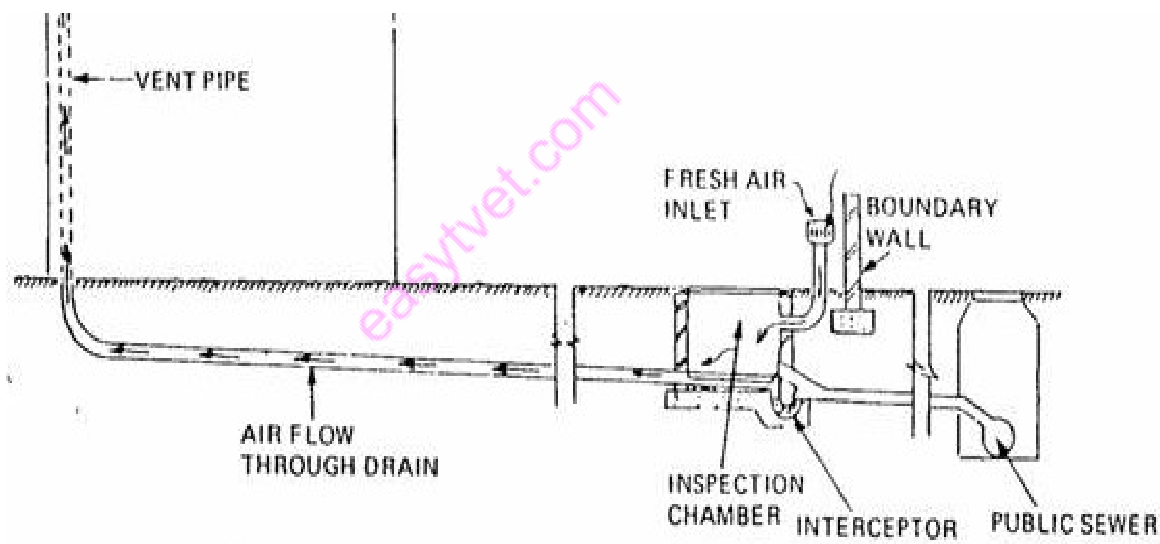
3.2.6.4. Learning Activities

Practical activities

Procedure

1. Assemble all tools and materials required
2. Set out the drainage system of a suitable depth as in the figure below.

Fig 4.6: Below ground drainage



Materials Required

May include but not limited to:

- Measuring tools
- Levelling equipment's

- Mason trowels
- Mason square
- Spirit level
- Boning rods
- Floats
- Mallet
- Ball hammer
- Masonry chisel

3.2.6.5. Self-Assessment

1. Which four tests would you apply when testing the functionality of a plumbing system?
2. What are the five disadvantages of manual installation for underground drainage?
3. Which three waterproofing material would you use to correct a leaking elbow?
4. What are the guiding principles when designing any drainage system?
5. How would you undertake the smoke test for below water drainage?

3.2.6.6. Tools, Equipment, Supplies and Materials

- Measuring tools
- Levelling equipment's
- Mason trowels
- Mason square
- Spirit level
- Boning rods
- Floats
- Mallet
- Ball hammer
- Masonry chisel

3.2.6.7. References

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3.2.6.8. Model Answers

1. Which four tests would you apply when testing the functionality of a plumbing system?
    - Water
    - Smoke
    - Air
    - Peppermint
2. What are the five disadvantages of manual installation for underground drainage?
    - Labour intensive
    - Slow
    - Limited depth. Only drain depth < 1.0 m
    - Limited to tough ground surfaces
    - More costly
3. Which three waterproofing material would you use to correct a leaking elbow?
    - Cement Waterproofing.
    - Bituminous Membrane
    - Teflon tape
    - Caulk

4. What are the guiding principles when designing any drainage system?

- Provide adequate access points.
- Keep pipework as straight as possible between access points and for all bends over 45º and access point should be provided.
- Ensure all pipework is adequately supported
- Ensure the pipe is laid to a self-cleansing gradient
- Ensure the drainage system is well ventilated

5. How would you undertake the smoke test for below water drainage?

- The smoke test is used both for testing the soundness of the system and for tracing a suspected leak. It can be used equally well for the testing of above ground soil, waste and vent pipes.
  All water seals must be charged with water and all branch drains and vents must be sealed except one. Smoke is then pumped into the system through a test plug which is fitted in the lowest point of the drain or stack.