

# **MATERIALS, PROCESSES AND WORKSHOP TECHNOLOGY.**

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## **TOPIC 1: OCCUPATIONAL SAFETY**

### **General workshop safety.**

#### **Introduction.**

Almost everyone working in a factory has at some stage in his or her career suffered an injury requiring treatment or first aid. It may have been a cut finger or something more serious. The cause may have been carelessness by the victim or a colleague, defective safety equipment, not using the safety equipment provided or inadequate protective clothing. Whatever the explanation given for the accident, the true cause was most likely a failure to think ahead. You must learn to work safely. Your workplace will have its own safety rules so always obey them. Ask if you do not understand any instruction and do report anything which seems dangerous, damaged, or faulty.

#### **Employer's responsibilities.**

1. To provide and maintain machinery, equipment and other plant, and systems of work that are safe and without risk to health. ('Systems of work' means the way in which the work is organised and includes layout of the workplace, the order in which jobs are carried out or special precautions to be taken before carrying out certain hazardous tasks.)
2. Ensure ways in which articles and substances (e.g., machinery and chemicals) are used, handled, stored, and transported are safe and without risk to health.
3. Provide information, instruction, training, and supervision necessary to ensure health and safety at work. *Information* means the background knowledge needed to put the instruction and training into context. *Instruction* is when someone shows others how to do something by practical demonstration. *Training* means having employees practise a task to improve their performance. *Supervision* is needed to oversee and guide in all matters related to the task.
4. Ensure any place under their control and where their employees' work is kept in a safe condition and does not pose a risk to health. This includes ways into and out of the workplace.
5. Ensure the health and safety of their employees' working environment (e.g., heating, lighting, ventilation, etc.). They must also provide adequate arrangements for the welfare at work of their employees (the term 'welfare at work' covers facilities such as seating, washing, toilets, etc.).

#### **Employee's responsibilities.**

1. To take reasonable care for their own health and safety and that of others who may be affected by what they do or don't do.

This duty implies not only avoiding silly or reckless behaviour but also understanding hazards and complying with safety rules and procedures. This means that you correctly use all work items provided by your employer in accordance with the training and instruction you received to enable you to use them safely.

1. To cooperate with their employer on health and safety.

This duty means that you should inform, without delay, of any work situation which might be dangerous and notify any shortcomings in health and safety arrangements so that remedial action may be taken.

### **Provision and use of work equipment.**

Work equipment has wide meaning and is broadly defined to include anything from a hand tool, through machines of all kinds, to a complete plant such as a refinery.

Provision and use of work equipment include:

- *The suitability of work equipment:*

Equipment must be suitable by design and construction for the actual work it is provided to do.
- *Maintenance of work equipment in good repair:*

From simple checks on hand tools such as loose hammer heads to specific checks on lifts and hoists. When maintenance work is carried out it should be done in safety and without risk to health.
- *Information and instruction on use of the work equipment:*

-Including instruction sheets, manuals or warning labels from manufacturers or suppliers. Adequate training for the purposes of health and safety in the use of specific work equipment.
- *Dangerous parts of machinery:*

Guarding machinery to avoid the risks arising from mechanical hazards. The principal duty is to take effective measures to prevent contact with dangerous parts of machinery by providing:

  - i) Fixed enclosing guards.
  - ii) Other guards or protection devices.
  - iii) Protection appliances (jigs, holders).

iv) Information, instruction, training, and supervision.

- *Protection against specified hazards:*

- i) Material falling from equipment.

- ii) Material ejected from a machine.

- iii) Parts of the equipment breaking off, e.g., grinding wheel bursting.

- iv) Parts of equipment collapsing, e.g., scaffolding.

- vi) explosion of equipment, e.g., failure of a pressure-relief device.

- vii) explosion of substance in the equipment, e.g., ignition of dust.

- *High and very low temperature:*

Prevent the risk of injury from contact with hot (blast furnace, steam pipes) or very cold work equipment (cold store).

- *Controls and control systems:*

Starting work equipment should only be possible by using a control and it should not be possible for it to be accidentally or inadvertently operated nor 'operate itself' (by vibration or failure of a spring mechanism).

-Stop controls should bring the equipment to a safe condition in a safe manner.

Emergency stop controls are intended to effect a rapid response to potentially dangerous situations and should be easily reached and activated. Common types are mushroom headed buttons, bars, levers, kick plates or pressure-sensitive cables.

-It should be possible to identify easily what each control does. Both the controls and their markings should be clearly visible and factors such as color, shape and position are important.

- *Isolation from source of energy:*

-To allow equipment to be made safe under particular circumstances, e.g., when maintenance is to be carried out or when an unsafe condition develops. Isolation may be achieved by simply removing a plug from an electrical socket or by operating an isolating switch or valve.

-Sources of energy may be electrical, pressure (hydraulic or pneumatic) or heat.

- *Stability:*

-There are many types of work equipment that might fall over, collapse or overturn unless they are fixed. Most machines used in a fixed position should be bolted down.

Some types of work equipment such as mobile cranes may need counterbalance weights.

-Ladders should be at the correct angle (a slope of four units up to each one out from the base), correct height (at least 1 meter above the landing place) and tied at the top or secured at the foot.

- *Lighting:*

If the lighting in the workplace is insufficient for detailed tasks then additional lighting will need to be provided, e.g., local lighting on a machine.

- *Markings:*

There are many instances where marking of equipment is appropriate for health and safety reasons, e.g., start/stop controls, safe working load on cranes or types of fire extinguishers.

- *Warnings:*

-Normally in the form of a permanent printed notice or similar, e.g., 'head protection must be worn' Portable warnings are also necessary during temporary operations such as maintenance.

-Warning devices can be used which may be audible, e.g., reversing alarms on heavy vehicles, or visible, e.g., lights on a control panel. They may indicate imminent danger, development of a fault or the continued presence of a potential hazard.

-They must all be easy to see and understand, and they must be unambiguous.

### **Workplace health, safety, and welfare.**

- *Working environment:*

- i. Ventilation.
- ii. Temperature in indoor workplace.
- iii. Lighting including emergency lighting.
- iv. Room dimensions and space.
- v. Suitability of workstations and seating.

- *Safety:*

- i. Safe passage of pedestrians and vehicles (e.g., traffic routes, must be wide enough and marked where necessary, and there must be enough of them).
- ii. Windows and skylights (safe opening, closing, and cleaning).
- iii. Transparent or translucent surfaces in doors and partitions (use of safety material and marking).
- iv. Doors, gates, and escalators (safety devices).

- v. Floors (construction and maintenance, obstructions and slipping and tripping hazards).
- vi. Falling from heights and into dangerous substances.
- vii. Falling objects.
- *Facilities*
  - i. Toilets.
  - ii. Washing, eating, and changing facilities.
  - iii. Clothing storage.
  - iv. Drinking water.
  - v. Rest areas (and arrangements to protect people from the discomfort of tobacco smoke).
- *Housekeeping*
  - i. Maintenance of workplace, equipment, and facilities.
  - ii. Cleanliness.
  - iii. Removal of waste materials.

**Workshop rules.**

1. Student affected by drugs or alcohol are not allowed in the workshop.
2. Students with any health problems that may affect the workshop safety must report these conditions to the workshop staff.
3. Notify the workshop staff of your arrival.
4. No food or drink in the workshop.
5. Wear correct protective equipment for the tools you are using. Ask if in doubt.
6. Immediately notify the technician of any fault or broken equipment.
7. Keep clear of any person operating tools and machinery.
8. Clean up any spills immediately.
9. Wash equipment/hands after using materials.
10. Keep walkways and workspaces stable and clear.
11. Use the tools and machines only for their intended purpose.
12. When exiting the workshop, check that any tools you have been using have been put away in the appropriate spots, cleaned up your work area and notify the workshop staff.

### **Clothing and footwear.**

1. Safety glasses and hearing protection.
2. Students wearing glasses should be aware these are not safety glasses. Safety glasses must be worn.
3. All loose clothing (e.g., shirts hanging) must be tucked in.
4. Safety boots or enclosed shoes must be worn in the workshop. There are no exceptions to this rule.
5. Long hair must be tied up.
6. Remove rings and long jewelry before operating machinery.

***Eye protection:*** Serves as a guard against the hazards of impact, splashes from chemicals or molten metal, liquid droplets (chemical mists and sprays), dust, gases, and welding arcs. Eye protectors include safety spectacles, eye-shields, goggles, welding filters, face shields and hoods.

***Head protection:*** Includes industrial safety helmets to protect against falling objects or impact with fixed objects; industrial scalp protectors to protect against striking fixed obstacles, scalping or entanglement and caps and hairnets to protect against scalping and entanglement.

***Foot protection:*** Includes safety boots or shoes with steel toe caps; foundry boots with steel toe caps, which are heat resistance and designed to keep out molten metal; wellington boots to protect against water and wet conditions and anti-static footwear to prevent the build-up of static electricity on the wearer.

***Hand protection:*** Gloves of various design provide protection against a range of hazards including cuts and abrasions; extremes of temperature (hot and cold); skin irritation and dermatitis and contact with toxic or corrosive liquids. Barrier creams may sometimes be used as an aid to skin hygiene in situations where gloves cannot be used.

***Protective clothing:*** Types of clothing used for body protection include coveralls, overalls, and aprons to protect against chemicals and other hazardous substances; outfits to protect against cold, heat and bad weather; and clothing to protect against machinery such as chain saws. Types of clothing worn on the body to protect the person include high visibility clothing, life jackets and buoyancy aids.

### **Causes of accidents.**

The accidents may take place due to human causes, environmental causes, and mechanical causes. These causes are discussed as under.

#### **Human Causes:**

1. Accidents may occur while working on unsafe or dangerous equipment or machineries possessing rotating, reciprocating, and moving parts.

2. Accidents occur while operating machines without knowledge, without safety precautions, without authority, without safety devices.
3. Accidents generally occur while operating or working at unsafe speed.
4. Accidents may occur while working for long duration of work, shift duty etc.
5. Accidents commonly occur during use of improper tools.
6. Accidents may occur while working with mental worries, ignorance, carelessness, nervousness, dreaming etc.
7. Accidents occur because of not using personal protective devices.

**Environmental Causes:**

1. Accidents may occur during working at improper temperature and humidity causing fatigue to the workers, so chances of accidents increase with workers having fatigue.
2. The presence of dust fumes and smoke in the working area may causes accidents.
3. Poor housekeeping, congestion, blocked exits, bad plant layout etc. may cause accidents.
4. Accidents occur due to inadequate illumination.
5. Improper ventilation in the plant may also leads to industrial accidents.

**Mechanical Causes:**

1. Continued use of old, poor maintained, or unsafe equipment may result in accidents.
2. Accidents commonly occur due to use of unguarded or improper guarded machines or equipment.
3. Unsafe processes, unsafe design and unsafe construction of building structure may lead to accidents in the plant.
4. Accidents occur due to improper material handling system and improper plant layout.
5. Accidents may occur due to not using of safety devices such as helmets, goggles, gloves, masks etc.

However, the other general causes of accidents in workshops are listed under:

1. Because of ignorance to work with equipment, hand tools, cutting tools and machine tools.
2. Operating machine and equipment without knowledge.
3. Extra curiosity to work without knowing.
4. Due to poor working conditions.
5. Because of speedy work.
6. Improper method to work.
7. Due to use of improper tools.
8. Because of lack of discipline.
9. Uninterested in work.
10. Due to carelessness.

11. Due to over confidence.
12. Bad working environment.
13. Because of excessive over times duty by industrial workers.
14. Dangerous materials with which to work.
15. Lack of cleanliness.
16. Due to poor planning.

### **Electrical safety.**

The major hazards arising from the use of electrical equipment are:

**Electric shock:** The body responds in several ways to electric current flowing through it, any one of which can be fatal. The chance of electric shock is increased in wet or damp conditions, or close to conductors such as working in a metal tank. Hot environments where sweat or humidity reduce the insulation protection offered by clothing increase the risk.

**Electric burn:** This is due to the heating effect caused by electric current passing through body tissue, most often the skin at the point of contact giving rise to the electric shock. **Fire:** Caused by electricity in several ways including, overheating of cables and electrical equipment due to overloading; leakage currents due to poor or inadequate insulation; overheating of flammable materials placed too close to electrical equipment; ignition of flammable materials by sparking of electrical equipment.

**Arcing:** Generates ultra-violet radiation causing a particular type of burn like severe sunburn. Molten metal resulting from arcing can penetrate, burn, and lodge in the flesh. Ultra-violet radiation can also cause damage to sensitive skin and to eyes, e.g., arc eye in metal arc welding.

**Explosion:** These include the explosion of electrical equipment, e.g., switchgear or motors, or where electricity causes the ignition of flammable vapors, gases, liquids and dust by electric sparks or high temperature electrical equipment.

### **Electrical precautions.**

Where it is possible for electrical equipment to become dangerous if a fault should arise, then precautions must be taken to prevent injury. These precautions include:

**Double insulation:** The principle is that the live conductors are covered by two discrete layers of insulation. Each layer would provide adequate insulation but together they ensure little likelihood of danger arising from insulation failure. This arrangement avoids the need for an earth wire. Double insulation is particularly suitable for portable equipment such as drills. However, safety depends on the insulation remaining in sound condition and the equipment must be properly constructed, used, and maintained.

**Earthing:** In the Kenya, the electricity supply is connected to earth. It is this system that enables earth faults on electrical equipment to be detected and the electrical supply to be cut off automatically. This

automatic cut-off is performed by fuses or automatic circuit breakers: if a fault occurs the fuse will blow and break the circuit. Although they do not eliminate the risk of electric shock, danger may be reduced using a residual current device (RCD) designed to operate rapidly at small leakage currents. RCDs should only be considered as providing a second line of defense. It is essential to regularly operate the test trip button to maintain their effectiveness.

***Use of safe voltages:*** Reduced voltage systems (110 volts) are particularly suitable for portable electrical equipment in construction work and in high conducting locations such as boilers, tunnels, and tanks; where the risk to equipment and trailing cables is high; and where the body may be damp.

### **Electrical shock and treatment.**

If the human body accidentally meets an electrical conductor which is connected to the supply, a current may, depending on the conditions, flow through the body. This current will at least produce violent muscular spasms which may cause the body to be flung across the room or fall off a ladder. In extreme cases the heart will stop beating.

Burns are caused by the current acting on the body tissue and internal heating can also take place leading to partial blockage of blood flow through the blood vessels. In the event of someone suffering electric shock know what to do – it should form part of your training.

#### ***In case of an electrical shock,***

1. Shout for help – if the casualty is still in contact with electric current, switch off or remove the plug.
2. If the current cannot be switched off, take special care to stand on a dry nonconducting surface and pull or push the victim clear using a length of dry cloth, jacket, or a broom. Remember: do not touch the casualty as you will complete the circuit and receive a shock.
3. Once free, if the casualty is breathing, put in recovery position and get the casualty to hospital; if the casualty is not breathing give mouth-to-mouth resuscitation, check pulse, and, if absent, apply chest compressions and call for medical assistance.

Posters giving the detailed procedure to be followed in the event of a person suffering electric shock must be permanently displayed in your workplace. With this and you're training you should be fully conversant with the procedures – remember it could save a life.

#### **Performing mouth to mouth.**

1. Make sure the is lying on a hard flat surface. Look into the mouth and throat to ensure that the airway is clear. If an object is present, try to sweep it with your fingers.
2. Tilt the head back slightly to open the airway. Put upward pressure on the jaws to pull it forward.

3. Pinch the nostrils closed, place your mouth tightly over the person's mouth. Blow two quick breaths and watch for the person's chest to rise.
4. Release the nostrils. Look for the person's chest to fall as he/she exhales. Listen for the sounds of breathing. Feel the person's breath on your cheek. If the person doesn't start breathing on his/her own, repeat the procedure.

### **Performing C.P.R.**

1. Make sure the patient is lying on his/her back on a firm surface. Kneel beside him and place the heel of your hand on the center of the chest (between nipples).
2. Interlock your fingers and keep your fingers raised so they do not touch the patient's ribcage.
3. Give chest compressions by leaning forward and pressing down on the chest about two inches and then releasing.
4. Repeat and give 30 compressions at a rate of 100 compressions per minute.

### **Holger-Nielsen method.**











- 1) This is done in prone position
- 2) Doctor kneels near patient's head, facing towards him
- 3) Doctor will pull his arms up .This will bring about Inspiration
- 4) Then doctor will leave his hands on side & put his palms on patient's scapulae & bending forward he will apply deep pressure on his chest .This will cause expiration.
- 5) Inspiration for 3 sec & Expiration for 2 sec .Say 1,2,3 & 1,2
- 6) Main advantage of this method is adequate drainage of water from abdomen & thorax .So this is a good method in cases of drowning
- 7) If there are injuries to abdomen ,this method can be used.

### **General electrical safety rules.**

- Ensure that a properly wired plug is used for all portable electrical equipment.
- Never improvise by jamming wires in sockets with nails or matches.
- Molded rubber plugs are preferable to the brittle plastic types since they are less prone to damage.
- All electrical connections must be secure, loose wires or connections can arc.
- A fuse of the correct rating must be fitted – this is your safeguard if a fault develops –never use makeshift fuses such as pieces of wire.
- Any external metal parts must be earthed so that if a fault develops, the fuse will blow and interrupt the supply.
- Never run power tools from lamp sockets.
- Connection between the plug and equipment should be made with the correct cable suited to the current rating of the equipment.

- Old or damaged cable should never be used.
- Equipment should always be disconnected from the mains supply before making any adjustment, even when changing a lamp.

**Safety signs and colours.**

Shape	Meaning	Color	Examples
 Circle with diagonal bar	Prohibition	RED (contrast: white)	No smoking 
 Circle	Mandatory Action	BLUE (contrast: white)	Wear Eye protection 
 Equilateral Triangle	Warning	YELLOW (contrast: black)	Danger Flammable material 
 Square / Rectangle	Information about safe condition	GREEN (contrast: white)	Escape Route – Left 
 Square / Rectangle	Fire Safety	RED (contrast: white)	Fire Extinguisher 

**Fire.**

Fire is a phenomenon in which combustible materials, especially organic materials containing carbon, react chemically with the oxygen in the air to produce heat. Flame arises from the combustion of volatile liquids and gases evolved and spreads the fire.

There are several reasons for fires starting:

1. Malicious ignition: i.e., deliberate fire raising.
2. Misuse or faulty electrical equipment; e.g. incorrect plugs and wiring, damaged cables, overloaded sockets and cables, sparking and equipment such as soldering irons left on and unattended.
3. Cigarettes and matches: smoking in unauthorized areas, throwing away lighted cigarettes or matches.
4. Mechanical heat and sparks: e.g., faulty motors, overheated bearings, sparks produced by grinding and cutting operations.
5. Heating plant: flammable liquids/substances in contact with hot surfaces.
6. Rubbish burning: casual burning of waste and rubbish.

There are several reasons for the spread of fire including:

1. Delayed discovery.
2. Presence of large quantities of combustible materials.
3. Lack of fire separating walls between production and storage areas.
4. Openings in floors and walls between departments.
5. Rapid burning of dust deposits.
6. Oils and fats flowing when burning.
7. Combustible construction of buildings.
8. Combustible linings of roofs, ceilings, and walls.

### **Fire prevention.**

The best prevention is to stop a fire starting:

1. Where possible use materials which are less flammable.
2. Minimize the quantities of flammable materials kept in the workplace or store.
3. Store flammable material safely, well away from hazardous processes or materials, and where appropriate, from buildings.
4. Warn people of the fire risk by a conspicuous sign at each workplace, storage area and on each container.
5. Some items, like oil-soaked rags, may ignite spontaneously; keep them in a metal container away from other flammable material.
6. Before welding or similar work remove or insulate flammable material and have fire extinguishers to hand.
7. Control ignition sources, e.g., naked flames and sparks, and make sure that 'no smoking' rules are obeyed.

8. Do not leave goods or waste to obstruct gangways, exits, stairs, escape routes and fire points.
9. Make sure that vandals do not have access to flammable waste materials.
10. Comply with the specific precautions for highly flammable gas cylinders such as acetylene.
11. After each spell of work, check the area for smoldering matter or fire.
12. Burn rubbish in a suitable container well away from buildings and have fire extinguishers to hand.
13. Never wedge open fire-resistant doors designed to stop the spread of fire and smoke.
14. Have enough fire extinguishers, of the right type and properly maintained, to deal promptly with small outbreaks of fire.

### **Firefighting.**



- ***Class A fires*** – freely burning fires fueled by ordinary combustible materials such as cloth, wood, paper, and fabric.
- ***Class B fires*** – fires fueled by flammable liquids such as oils, spirits, and petrol.
- ***Class C fires*** – fires fueled by flammable gases such as propane, butane, and North Sea gas.
- ***Class D fires*** – fires involving flammable metals such as Magnesium, Lithium or Aluminium powders or swarf. Fires involving electrical hazards.
- ***Class F fires*** – fires fueled by cooking oils and fats. Use of a wet chemical is the most effective way of extinguishing this type of fire.

# Types of fire extinguisher and their uses

## WATER

Used on paper, wood, coal, cardboard and other solid fuel fires.



Solid Red

Can be used on:  
Class A

## FOAM

Used on solid fuel fires as well as flammable liquids.



Cream

Can be used on:  
Class A  
Class B

## POWDER

Used on any kind of fire except for Class F cooking oils.



Blue

Can be used on:  
Class A  
Class B  
Class C  
Class D  
Electrical

## CO<sub>2</sub>

Used on flammable liquids and electrical fires.



Black

Can be used on:  
Class B  
Electrical

## WET CHEMICAL

Used on cooking oil fires as well as combustible solid materials.



Yellow

Can be used on:  
Class A  
Class F



### Class A

Combustible materials. These include paper, textiles, wood and similar materials.



### Class B

Flammable liquids. These include petrol, oil and paint.



### Class C

Flammable gases. These include butane and methane.



### Class D

Flammable metals. These include potassium and uranium.



### Electrical

Electrical goods. These include appliances in kitchens as well as computers, phones etc.



### Class F

Cooking oils. These include chip pan fires and deep fat fryers.

## **TOPIC 2: MATERIALS AND PROCESSES.**

### **2.1 Metals and non-metals.**

#### ***a. Metals:***

Metals are opaque, lustrous elements that are good conductors of heat and electricity. Most metals are malleable and ductile and are, in general, denser than the other elemental substances.

#### ***b. Non-metals:***

A non-metal is an element that is generally a poor conductor of heat and electricity. Most properties of nonmetals are the opposite of metals.

#### ***c. Alloys.***

An alloy is a mixture composed of two or more elements, at least one of which is a metal.

Examples of common alloys:

- Steel: A combination of iron (metal) and carbon (non-metal)
- Bronze: A combination of copper (metal) and tin (metal)
- Brass: A mixture of copper (metal) and zinc (metal)

#### ***d. Ferrous and non-ferrous metals.***

Ferrous metals contain iron and non-ferrous metals do not contain iron.

#### ***Which Metals Are Ferrous?***

Some common ferrous metals include alloy steel, carbon steel, cast iron and wrought iron. These metals are prized for their tensile strength and durability. Carbon Steel – also known as structure steel – is a staple in the construction industry and is used in the tallest skyscrapers and longest bridges. Ferrous metals are also used in shipping containers, industrial piping, automobiles, railroad tracks, and many commercial and domestic tools.

Ferrous metals have a high carbon content which generally makes them vulnerable to rust when exposed to moisture. There are two exceptions to this rule: wrought iron resists rust due to its purity and stainless steel is protected from rust by the presence of chromium.

Most ferrous metals are magnetic which makes them very useful for motor and electrical applications.

### Steel:

Steel is made by adding iron to carbon which hardens the iron. Alloy steel becomes even tougher as other elements like chromium and nickel are introduced. Steel is made by heating and melting iron ore in furnaces. The steel can is tapped from the furnaces and poured into molds to form steel bars. Steel is widely used in the construction and manufacturing industries.

### Carbon Steel:

Carbon steel has a higher carbon content in comparison to other types of steel making it exceptionally hard. It is commonly used in the manufacturing of machine tools, drills, blades, taps, and springs. It can keep a sharp cutting edge.

### Alloy Steel:

Alloy steels incorporate elements such as chromium, nickel and titanium to impart greater strength and durability without increasing weight. Stainless steel is an important alloy steel made using chromium. Alloy steels are used in construction, machine tools, and electrical components.

### Cast Iron:

Cast iron is an alloy made from iron, carbon, and silicon. Cast iron is brittle and hard and resistant to wear. It's used in water pipes, machine tools, automobile engines and stoves.

### Wrought Iron:

Wrought iron is an alloy with so little carbon content it's almost pure iron. During the manufacturing process, some slag is added which gives wrought iron excellent resistance to corrosion and oxidation, however, it is low in hardness and fatigue strength. Wrought iron is used for fencing and railings, agricultural implements, nails, barbed wire, chains, and various ornaments.

### ***Which Metals Are Non-Ferrous?***

Non-ferrous metals include aluminum, copper, lead, zinc, and tin, as well as precious metals like gold and silver. Their main advantage over ferrous materials is their malleability. They also have no iron content, giving them a higher resistance to rust and corrosion, and making them ideal for

gutters, liquid pipes, roofing, and outdoor signs. Lastly, they are non-magnetic, which is important for many electronic and wiring applications.

Aluminum:

Aluminum is lightweight, soft, and low strength. Aluminum is easily cast, forged, machined, and welded. It's not suitable for high-temperature environments. Because aluminum is lightweight, it is a good choice for the manufacturing of aircraft and food cans. Aluminum is also used in castings, pistons, railways, cars, and kitchen utensils.

Copper:

Copper is red in color, highly ductile, malleable and has high conductivity for electricity and heat. Copper is principally used in the electrical industry in the form of wire and other conductors. It's also used in sheet roofing, cartridge cases, statues, and bearings. Copper is also used to make brass, an alloy of copper and zinc.

Lead:

Lead is a soft, heavy, malleable metal with a low melting point and low tensile strength. It can withstand corrosion from moisture and many acids. Lead is widely used in electrical power cables, batteries, building construction and soldering.

Zinc:

Zinc is a medium to low strength metal with a very low melting point. It can be machined easily, but heating may be required to avoid cleavage of crystals. Zinc is most widely used in galvanizing, the process of applying a protective zinc coating to iron or steel to prevent rust.

Tin:

Tin is very soft and malleable, ductile with low tensile strength. It's often used to coat steel to prevent corrosion. Tinplate steel is used to make tin cans to hold food. In the late 19th century, tin foil was commonly used to wrap food products, but has since largely been replaced by aluminum foil. Tin can also be alloyed with copper to produce tin brass and bronze.

## **2.2 Properties of materials.**

*Physical properties* are measurable. Those are things like density, melting point, conductivity, coefficient of expansion, etc. *Mechanical properties* are how the metal performs when different forces are applied to them. That includes things like strength, ductility, wear resistance, etc. The mechanical and physical properties of materials are determined by their chemical composition and their internal structure, like grain size or crystal structure.

**a. Conductivity:**

Thermal conductivity is a measure of the quantity of heat that flows through a material.

**b. Corrosion Resistance:**

Corrosion resistance describes a material's ability to prevent natural chemical or electro-chemical attack by atmosphere, moisture or other agents.

**c. Density:**

Density, often expressed as pounds per cubic inch, or grams per cubic centimeter, etc., describes the mass of the alloy per unit volume. The density of the alloy will determine how much a component of a certain size will weigh.

**d. Ductility:**

Ductility is the ability of a material to deform plastically (that is, stretch) without fracturing and retain the new shape when the load is removed. Think of it as the ability to stretch a given metal into a wire. (Tensile stress)

**e. Malleability:**

A physical property describes a metal's ability to be formed without breaking. Pressure, or compressive stress, is used to press or roll the material into thinner sheets. A material with high malleability will be able to withstand higher pressure without breaking. (Compressive stress)

**f. Elasticity:**

Elasticity describes a material's tendency to return to its original size and shape when a distorting force is removed. As opposed to materials that exhibit plasticity (where the change in shape is not reversible), an elastic material will return to its previous configuration when the stress is removed.

The stiffness of a metal is the ability of an object to resist deformation in response to an applied force; rigidity; complementary to flexibility

***g. Toughness:***

It is the ability of a material to absorb the energy and gets plastically deformed without fracturing.

***h. Hardness:***

Hardness is defined as a material's ability to resist permanent indentation (that is plastic deformation). Typically, the harder the material, the better it resists wear or deformation. The term hardness, thus, also refers to local surface stiffness of a material or its resistance to scratching, abrasion, or cutting.

***i. Plasticity:***

Plasticity, the converse of elasticity, describes the tendency of a certain solid material to hold its new shape when subjected to forming forces. It is the quality that allows materials to be bent or worked into a permanent new shape. Materials transition from elastic behavior to plastic at the yield point.

***j. Strength:***

It is the property of a material which opposes the deformation or breakdown of material in presence of external forces or load.

***k. Tensile Strength:***

Tensile strength refers to the amount of load a section of metal can withstand before it breaks.

***l. Toughness:***

Toughness represents a material's ability to absorb impact without fracturing at a given temperature.

***m. Wear Resistance:***

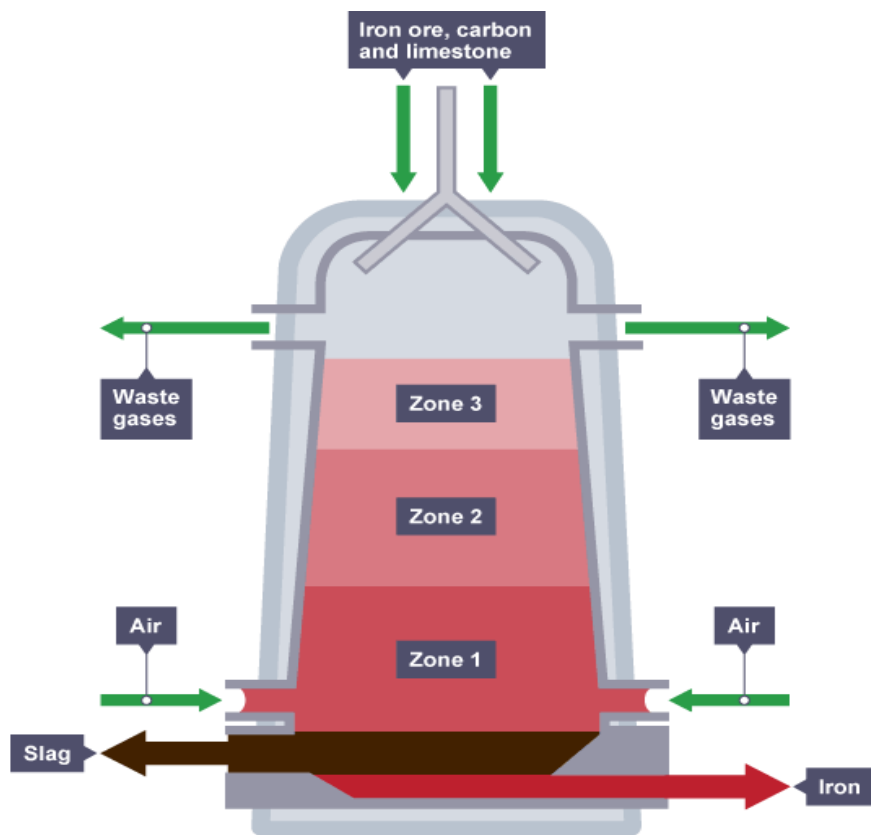
Wear resistance is a measure of a material's ability to withstand the effect of two materials rubbing against each other. This can take many forms including adhesion, abrasion, scratching, gouging, galling, and others.

***n. Brittleness:***

Brittleness of a material indicates that how easily it gets fractured when it is subjected to a force or load. When a brittle material is subjected to a stress it observes very less energy and gets fractures without significant strain. Brittleness is converse to ductility of material. Brittleness of material is temperature dependent. Some metals which are ductile at normal temperature become brittle at low temperature.

## 2.3 Extraction Process.

### a. Extraction of Iron.



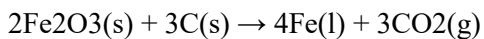
### The blast furnace.

Iron is extracted from iron ore in a huge container called a blast furnace. Iron ores such as haematite contain iron(III) oxide,  $\text{Fe}_2\text{O}_3$ .

The oxygen must be removed from the iron(III) oxide to leave the iron behind. Reactions in which oxygen is removed are called reduction reactions.

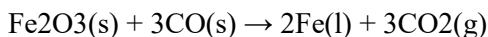
Carbon is more reactive than iron, so it can displace iron from iron(III) oxide. Here are the equations for the reaction:

Iron(III) oxide + carbon  $\rightarrow$  iron + carbon dioxide



In this reaction, the iron(III) oxide is reduced to iron, and the carbon is oxidised to carbon dioxide. In the blast furnace, it is so hot that carbon monoxide can be used, in place of carbon, to reduce the iron(III) oxide:

iron(III) oxide + carbon monoxide → iron + carbon dioxide



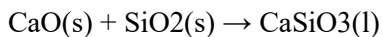
The calcium carbonate in the limestone thermally decomposes to form calcium oxide.

calcium carbonate → calcium oxide + carbon dioxide



The calcium oxide then reacts with silica (sand) impurities in the haematite, to produce slag - which is calcium silicate.

calcium oxide + silica → calcium silicate



### Raw materials for the reaction

Raw material	Contains	Function
Iron ore (haematite)	Iron(III) oxide	A compound that contains iron
Coke	Carbon	Burns in air to produce heat, and reacts to form carbon monoxide (needed to reduce the iron oxide)
Limestone	Calcium carbonate	Helps to remove acidic impurities from the iron by reacting with them to form molten slag
Air	Oxygen	Allows the coke to burn, and so produces heat

In summary:

The blast furnace operates at 1900 °C in order to smelt iron from iron ore. To attain that temperature, coke (and not coal) is used as fuel, and the fire inside the furnace is fanned with hot

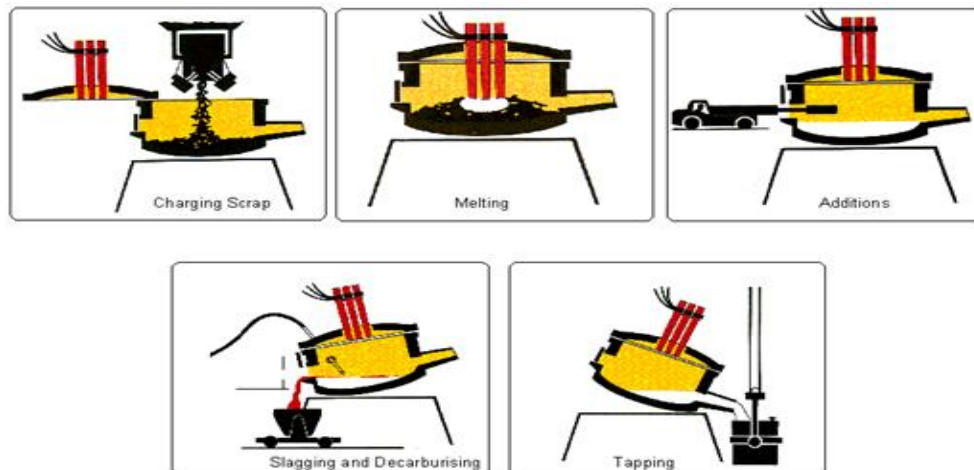
air at 1200 °C to 1300 °C degrees. Lime is added as an additional component; it binds contaminants. The blast furnace is fed from the top, so that alternating layers of coke and iron ore are formed. The highest temperature occurs in the lower part of the furnace. The liquid iron, on which the slag floats, collects at the base.

### *b. Extraction of steel.*

The basic raw material for steel manufacture is either the hot metal from the blast furnace, steel scrap or a mixture of both. The proportions of material used vary according to the process and the type of steel required. Steel can be described in general terms as iron with most of the carbon removed, to make it tougher and more ductile. There are many forms (grades) of steel, each with its own specific chemical composition and properties to meet the needs of the many different applications.

#### *Electric arc furnace method of making steel:*

The electric arc furnace consists of a circular bath with a movable roof, through which three graphite electrodes can be raised or lowered. At the start of the process, the electrodes are withdrawn, and the roof swung clear. The steel scrap is then charged into the furnace from a large steel basket lowered from an overhead travelling crane. When charging is complete, the roof is swung back into position and the electrodes lowered into the furnace. A powerful electric current is passed through the charge, an arc is created, and the heat generated melts the scrap. Lime and fluorspar are added as fluxes and oxygen is blown into the melt. As a result, impurities in the metal combine to form a liquid slag.



### c. Extraction of aluminium.

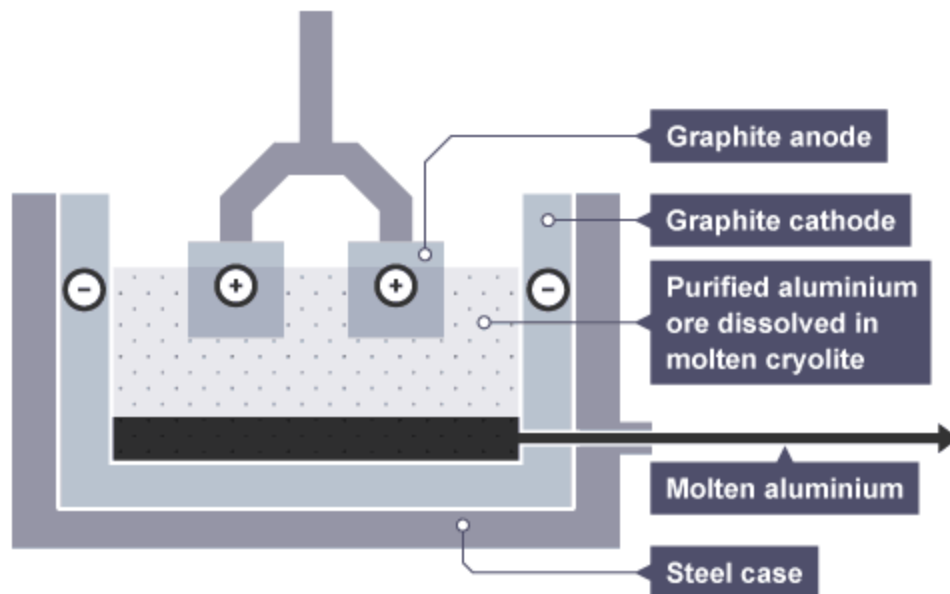
Aluminium is the most abundant metal on Earth, but it is expensive, largely because of the amount of electricity used in the extraction process.

Aluminium ore is called bauxite ( $\text{Al}_2\text{O}_3$ ). The bauxite is purified to yield a white powder – aluminium oxide (also known as alumina) – from which aluminium can be extracted.

The extraction is done by electrolysis, but first the aluminium oxide must be melted so that electricity can pass through it. However, aluminium oxide has a very high melting point (over  $2,000^\circ\text{C}$ ) so it would be expensive to melt it.

Instead, it is dissolved in molten cryolite – an aluminium compound with a lower melting point than aluminium oxide. The use of molten cryolite as a solvent reduces some of the energy costs involved in extracting aluminium by allowing the ions in aluminium oxide to move freely at a lower temperature.

A steel case is lined with a graphite cathode and filled with purified aluminium ore dissolved in molten cryolite. Graphite anodes are inserted, and molten aluminium is drawn off from the bottom.



The diagram shows an aluminium oxide electrolysis cell. Both the negative electrode (cathode) and positive electrode (anode) are made of graphite, which is a form of carbon.

Aluminium ions receive electrons at the negative electrode and are reduced to aluminium atoms:



The molten aluminium sinks to the bottom of the cell, where it is tapped off.

Oxide ions lose electrons at the positive electrodes and are oxidised to oxygen gas:



This oxygen reacts with the carbon of the positive electrodes, forming carbon dioxide, so they gradually burn away. As a result, the positive electrodes have to be replaced frequently. This adds to the cost of the process.

#### d. Extraction of copper:

- Mining: The ore is removed from the ground in either open pit or underground mines. Underground – sinking a vertical shaft into the earth to reach the copper ore and driving horizontal tunnels into the ore. Open-pit – 90% of ore is mined using the open pit method. Ores near the surface can be quarried after removal of the surface layers.
- The ore: An ore is a rock that contains enough metal to make it worthwhile extracting.
- Grinding: The ore is crushed, then ground into powder.
- Concentrating: The ore is enriched using a process called froth flotation. Unwanted material (called gangue) sinks to the bottom and is removed.
- Roasting: This is where the chemical reactions start. The powdered, enriched ore is heated in air between 500°C and 700°C to remove some sulphur and dry the ore, which is still a solid called calcine.
- Smelting with fluxes: A flux is a substance which is added to the ore to make it melt more easily. The solid calcine is heated to 1200°C and melts. Some impurities are removed forming a matte (a mixture of liquid copper and iron sulphide).
- Conversion of matte: Air is blown into the liquid matte forming blister copper, so called because the gas bubbles trapped in the solid form blisters on the surface.
- Anode casting: The blister is cast into anodes for electrolysis.
- Electrolytic refining: The copper is purified to 99.99% by electrolysis. The production route described above shows the progression from a rock containing about 0.2% copper to a copper cathode of 99.99% purity.

### *e. Bronze.*

Bronze is one of the earliest metals known to man. It is defined as an alloy made of copper and another metal, usually tin. Compositions vary, but most modern bronze is 88% copper and 12% tin. Bronze may also contain manganese, aluminum, nickel, phosphorus, silicon, arsenic, or zinc.

### *f. Plastics.*

Plastics are derived from natural, organic materials such as cellulose, coal, natural gas, salt and, of course, crude oil. Crude oil is a complex mixture of thousands of compounds and needs to be processed before it can be used.

The production of plastics begins with the distillation of crude oil in an oil refinery. This separates the heavy crude oil into groups of lighter components, called fractions. Each fraction is a mixture of hydrocarbon chains (chemical compounds made up of carbon and hydrogen), which differ in terms of the size and structure of their molecules. One of these fractions, naphtha, is the crucial compound for the production of plastics.

Two main processes are used to produce plastics - polymerisation and polycondensation - and they both require specific catalysts. In a polymerisation reactor, monomers such as ethylene and propylene are linked together to form long polymer chains. Each polymer has its own properties, structure and size depending on the various types of basic monomers used. There are many different types of plastics, and they can be grouped into two main polymer families:

- Thermoplastics (which soften on heating and then harden again on cooling).
- Thermosets (which never soften once they have been moulded).

## **2.4 Finishes and decorative process.**

### *a. Annealing.*

This process is carried out to soften the steel so that it may be machined or so that additional cold-working operations such as pressing and bending can be carried out.

### *b. Lacquering.*

Many metals suffer from surface tarnishing and even corrosion, if left open to the atmosphere / air. Surfaces can be protected through the application of different finishes, such as paint or powder coating.

However, sometimes the surface of metals can be attractive without the need for a coloured coating. This is when lacquer is most useful. Lacquer is usually applied as a clear coating, leaving the surface texture on view. Lacquer forms a protective clear layer on metals and is particularly useful on brass, aluminum, silver and copper, which are often in the form of decorative items. When lacquered, polishing and cleaning will no longer be required.

### *c. Enameling.*

Enameling is the process of applying a thin coat of finely ground glass to a metal. When heated to a high temperature, the glass melts and fuses to the metal. Enamels applied to metals produce various color effects. Copper has been the most inexpensive and satisfactory metal for use in enameling. It is easy to cut and shape and offers the fewest problems in fusing the enamels to its surface. Fine or pure silver sheet and gold can be enameled very satisfactorily, but the cost may be prohibitive.



Enameling.

### *d. Etching.*

Etching is a method of using chemicals to cut a design or pattern into a metal surface. Etchant is the chemical (or mixture of chemicals) used to cut into unprotected parts of the metal to create the finished etched design. A resist is what you use to protect certain parts of your metal from the etchant. Resists are typically inks (and tapes).



Etching.

### *e. Polishing.*

Metal polishing is a finishing method that uses an abrasive material to smooth surfaces. When polished, the surfaces of metallic objects are freed of defects and become more reflective and

shinier, enhancing their appearance. Metal polishing can be complemented by buffing, a less harsh method that results in a brighter finish.

Aside from its cosmetic value, metal polishing also serves a practical purpose. Beneath the surface, it removes oxidation from and prevents further corrosion of a metal, significantly prolonging its working life.

More on polishing: [The Basics of Metal Polishing \(helandermetal.com\)](http://helandermetal.com)

#### *f. Electroplating.*

Electroplating is the process of plating one metal onto another by hydrolysis, most commonly for decorative purposes or to prevent corrosion of a metal. There are also specific types of electroplating such as copper plating, silver plating, and chromium plating. Electroplating allows manufacturers to use inexpensive metals such as steel or zinc for most of the product and then apply different metals on the outside to account for appearance, protection, and other properties desired for the product. The surface can be a metal or even plastic.

The Purposes of Electroplating:

- Appearance
- Protection
- Special surface properties
- Engineering or mechanical properties

More on electroplating: [Electroplating - Chemistry LibreTexts](#)

#### *g. Coloring.*

Chemical coloring of metals is the process of changing the color of metal surfaces with different chemical solutions.

The chemical coloring of metals can be split into two types:

- Electroplating - coating the metal surface with another metal using electrolysis.
- Patination - chemically reacting the metal surface to form a colored oxide or salt.

Chemically coloring a metal is distinct from simply coating it using a method such as gilding or mercury silvering, because chemical coloring involves a chemical reaction, whereas simple coating does not.

More on coloring metals: [Chemical coloring of metals - Wikipedia](#)

#### ***h. Pickling and cleaning.***

Pickling is a metal cleaning process that uses very strong acids to clean the metal of certain types of surface conditions. These conditions include mill scale, oxides, impurities and stains. The solution of acid used when pickling is called the pickling liquor. During the process, the metal is submerged in the pickle liquor for a set amount of time and then removed.

### **2.5 Electrical materials and application.**

#### ***a. Conductors and application.***

Conductors are the materials or substances which allow electricity to flow through them. They conduct electricity because they allow electrons to flow easily inside them from atom to atom. Also, conductors allow the transmission of heat or light from one source to another.

#### ***b. Conductors and application.***

Insulators are the materials or substances which resist or don't allow the current to flow through them. Wood, cloth, glass, mica, and quartz are some good examples of insulators. Also, insulators are protectors. They give protection against heat, sound and of course passage of electricity. Furthermore, insulators don't have any free electrons. It is the main reason why they don't conduct electricity.

As insulators resist the flow of electron, they find worldwide applications. Some of the common uses include:

- Thermal insulators, disallow heat to move from one place to another. Hence, we use them in making thermoplastic bottles. They are also used in fireproofing ceilings and walls.
- Sound insulators help in controlling noise level, as they are good in absorbance of sound. Thus, we use them in buildings and conference halls to make them noise-free.
- Electrical insulators hinder the flow of electron or passage of current through them. So, we use them extensively in circuit boards and high-voltage systems. They are also used in coating electric wire and cables.

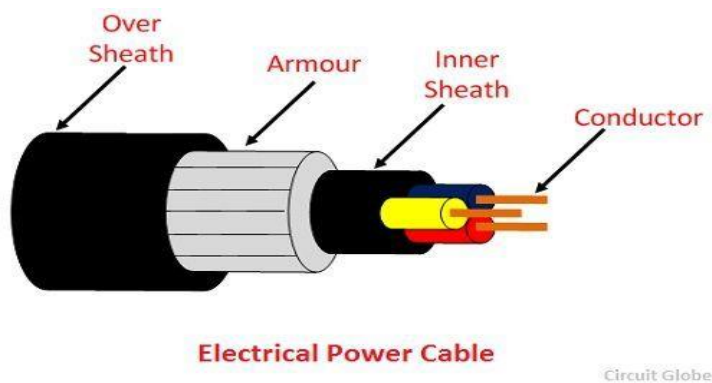
#### ***c. Semi-conductors.***

Semiconductor materials such as silicon (Si), germanium (Ge) and gallium arsenide (GaAs), have electrical properties somewhere in the middle, between those of a "conductor" and an "insulator".

They are not good conductors nor good insulators (hence their name “semi”-conductors). They have very few “free electrons” because their atoms are closely grouped together in a crystalline pattern called a “crystal lattice” but electrons are still able to flow, but only under special conditions.

#### d. Construction of cables.

The power cable mainly consists of three main components, namely, conductor, dielectric, and sheath. The conductor in the cable provides the conducting path for the current. The insulation or dielectric withstands the service voltage and isolates the conductor with other objects. The sheath does not allow the moistures to enter and protects the cables from all external influences like chemical or electrochemical attack, fire, etc.



#### e. Cable sizes.

The electrical cables used to power the lights and appliances in your home come in several different cable sizes, primarily to accommodate the amount of current required to run the items that are drawing power from it.

All cables are rated to carry a specific amperage meaning that the load imposed on them should be no more than they are able to safely carry.

The Cable sizes for domestic lighting circuits is usually 1mm or 1.5mm twin and earth cable (aka two core and earth). In most cases 1mm should be fine but depends on how many lights are on the circuit and how long the cable run is.

In most domestic situations the cable size used for sockets on a ring main or radial main is 2.5mm twin and earth cable.

Aside from the 3 most commonly used cable sizes of 1, 1.5 and 2.5mm twin and earth there are in fact several other larger sizes of cable that include 4mm, 6mm, 10mm and 16mm. These are mostly used for appliances and objects that require much more electrical power to operate or special use situations. Even larger sizes of cable include 25, 35, 50, 70,95, 120, 150 all the way up to 1000 square mm, over 20 different sizes in total.

The situations in which you would use a larger cable size really depends. As mentioned, appliances such as electric power showers, large cookers, electric car chargers etc will all draw larger amounts of current so will generally require a larger size cable to supply the required current and prevent too much current being drawn which can cause overheating and the potential for the cable to catch fire!

More here: [Electric Cable Sizes and Amp Ratings | Electrical Resistance and Cable Rating Tables | DIY Doctor](#)

## **2.6 Metal forming processes.**

### **a. Casting.**

Casting is a process that involves pouring liquid metal into a mold, containing a hollow cavity of the desired shape.

### **b. Forging.**

Forging involves shaping metals using localized, compressive forces after heating the metal to a point where it's malleable.

### **c. Stamping.**

Stamping is the process of placing a flat sheet (or coil) of metal into a stamping press, where a tool and die apply pressure to form the metal into a new shape, or cut out a piece of the metal.

### **d. Foundry work.**

Foundry work is the process of making a metal casting of an object by pouring molten metal into a mould.

## **2.7 Revision Questions.**

1. Describe the following finishes and decorative processes:

- i. Annealing.
- ii. Pickling.
- iii. Electroplating.

2. Explain the following metal forming processes:

- i. Forging.
- ii. Foundry work.

3. State:

- i. Two properties of aluminium.
- ii. Three classifications of electrical materials.

4. With the aid of a labelled diagram, describe the extraction of iron from its ore.

5.
  - i. Explain the term corrosion.
  - ii. List three factors that determine corrosion of metals.

6. Explain the following properties of engineering materials:

- i. Hardness.
- ii. Malleability.
- iii. Ductility.
- iv. Toughness.
- v. Conductivity.

7. 

- i. State two reasons why 'finishing' is done on an engineering product.

- ii. Distinguish between lacquering and enamelling finishing processes.

9. Describe two techniques of filing.

10. Draw a labelled diagram showing the extraction of aluminium by electrolysis.

11. With aid of a well labelled diagram, explain the process of electroplating a workpiece.

12. Distinguish between 'forging' and 'casting' with reference to metalwork.

13. Distinguish between cast iron and wrought iron.

14. State two:

- i. Properties of copper.
- ii. Applications of rubber.

15. i. State four properties of engineering materials.

ii. Distinguish between non-metals and alloys giving an example of each.

16. Name two copper alloys used in engineering work.

17. Distinguish between ferrous and non-ferrous metals.

## **TOPIC 3: METAL SHOP TOOLS AND MEASUREMENT.**

### **3.1 Terms used in measurement.**

#### *a. Scale.*

The ratio of the length in a drawing (or model) to the length on the real thing.

- Linear and non-linear scales:

A linear scale is a scale that consists of equally spaced divisions, sections or proportions. Each line, grid or marking you see are equal in value or size.

A non-linear scale consists of unequally space divisions, sections or proportions. This means that the lines, grids or markings you see are not equal or constant in value or size.

More on linear and non-linear scales: [Linear Vs. Non-Linear Scale | Science Zone Jamaica \(wordpress.com\)](#)

#### *b. Tolerance.*

“Tolerance” in engineering and manufacturing is the extent by which a value is permitted to vary. Specifying tolerance defines the acceptable limits of variance required for a particular project. For example, if a project requires pipes of 12.2m in length, the specified tolerance, or allowable variation from that value, may be  $\pm 100\text{mm}$ .

#### *c. Limits and Fits.*

Limits and fits describe the allowance between the shaft and the hole. Allowance, in turn, is the maximum dimensional difference between the diameters of the two. There are three types of shaft-hole fits:

- **Clearance fit:** This type of fit requires a shaft diameter to be smaller than that of the hole. Meaning that there will always be a gap between the two.
- **Transition fit:** This option means that the maximum shaft size is bigger than the minimum size of the hole. At the same time, the minimum shaft size is also smaller than the maximum size of the hole.
- **Interference fit:** Here, the shaft diameter size is always bigger than the hole. Even when the shaft is at its minimum diameter and the hole at its largest.

An interference fit ensures there is no movement between the two parts. Application of force is necessary during the physical fitting. Heating of the hole, freezing of the shaft and using a lubricant can all help to ease the process.

More on tolerance, limits and fits: [Engineering Tolerances | Limits, Fits and GD&T Explained | Fractory](#)

### **3.2 Marking out techniques.**

Marking out is the scratching of lines on the surface of a workpiece, known as scribing, and is usually carried out only on a single workpiece or a small number of workpieces.

The two main purposes of marking out are:

- *to indicate the workpiece outline* or the position of holes, slots, etc. If the excess material will have to be removed, a guide is given for the extent to which hacksawing or filing can be carried out.
- To provide a *guide to setting up the workpiece on a machine*. The workpiece is set up relative to the marking out and is then machined.


Scribed lines are only a guide, and any accurate dimension must be finally checked by measuring.

#### **3.2.1 Use of Rulers.**

A ruler is a measuring instrument consisting of a thin strip of wood, metal, or plastic that has a straight edge and length measurement markings along the edge. Rulers are sometimes referred to as a rule or line gauge.


Rulers are used for three main purposes: to measure, to aid in drawing straight lines, and as a straight guide for cutting and scoring with a blade.

## Types of Rulers.



# 17




## Types Of Rulers & Its Uses



- ### 01 Machinist ruler

The machinist scale ruler looks very much like an ordinary ruler. But it enables you to measure an object accurately and quickly, unlike ordinary ruler.
- ### 02 Flexible ruler

The flexible ruler is made of bendable material for measuring uneven surfaces. They are often used by masons and perfect for work that requires precision and measuring small objects.



### 03 Hook ruler

The measurement instrument you can always trust for joinery and general layout work.

### 04 Desk ruler

If you need to just draw straight lines or measure simple and small items for basic purposes, a desk ruler should be your first choice.

### 05 Steel ruler

A steel rule is the simplest and most common measuring device among all the others. They are more durable than desk ruler for use in the workshop since they are made of metal.

### 06 Yardsticks or meter sticks

They are commonly used in the construction industry and involved for work piece on a medium scale. Yardsticks are determined to measure customary units of length.



## 08 Narrow ruler

It is best to reach tight and hardly accessible spots to make it easier obtaining the correct and reliable measurement. In style, they are small, thin and flexible.

## 09 Seamstress tape

The main usage of this tape is by tailors for sewing and craft projects.

## 10 Steel Measuring tape

This convenient and simple measuring tool will help you measure the length of many things that are 12' to 35' in length for general purposes without putting in a lot of effort.

## 11 Protractor

Rulers do not always measure the straight lines. Sometimes, we need to measure the angles of items in degrees.



## 12 The set squares

A set square or right-angled triangle ruler is an instrument that is used in engineering and mechanical drawing as a guide for accurate results.

## 13 Rolling parallel ruler

A multi-purpose ruler that combines a ruler, protractor, and template all in one is available for students, artists, and designers.

## 14 Shrink ruler

Shrink rule is a special tool for pattern makers to facilitate the making patterns. Since metals decrease in volume while cooling, patterns are required to be made a little larger than the actual size of required casting to allow shrinkage.

## 15 Architect scale

Before they are built, the actual size of roads, water mains, structures, and fire protection systems are reduced in manageable size in drawing to facilitate the study since life-size drawings would be inappropriate.

## 16 Curved rulers

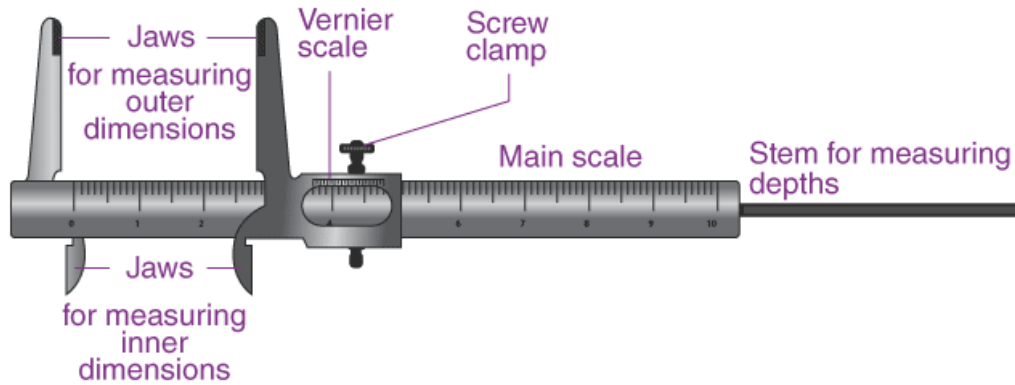
They are another essential tool used in sewing and dressmaking industry. The idea behind it is to get the job done much better than simple straight rulers could.

## 17 Caliper rule

The instrument is made of two hinged legs with adjustable outside and inside jaws to fit across the points to be measured.



### 3.2.2 The Vernier Calliper.



French mathematician Pierre Vernier invented the vernier scale in 1631. The main use of the vernier calliper over the main scale is to get an accurate and precise measurement.

#### ***Least Count of Vernier Calliper***

The least count of vernier callipers is also known as the vernier constant. It is defined as the difference between one main scale division and one vernier scale division.

It is mathematically given as:

$$VC = 1 \text{ MSD} - 1 \text{ VSD}$$

Where:

- VC is the vernier constant.
- MSD is the main scale division.
- VSD is the vernier scale division.

#### ***What is Zero Error?***

Zero error is defined as the condition in which the measuring device registers a reading when there should not be any reading.

The zero error of vernier calliper is calculated as:

Actual reading = Main scale + Vernier scale – (Zero error)

There are two types of zero error:

Positive zero error: When the jaws of the vernier calliper are closed and the reading is positive and away from the actual reading of 0.00 mm. For instance, if the reading is 0.08 mm, then the zero error is +0.08 mm.

Negative zero error: When the jaws of the vernier calliper are closed and the reading is negative and away from the actual reading of 0.00 mm. For instance, if the reading is 0.10 mm, then the zero error is - 0.10 mm.

Solved Examples

**Example 1:**

If the jaws of the vernier callipers are in contact with each other, then determine the zero error of the vernier calliper if the VSD is 3.

**Solution:**

Given:

The jaws of the vernier calliper are in contact with each other.

Therefore, the least count of the vernier calliper is given as:

$$LC = MSD - VSD$$

$$LC = 1 - (9/10) = 0.1 \text{ mm}$$

The main scale reading, MSR = 0 mm

The vernier scale reading, VSR = 3

Therefore,

$$\text{Zero error} = MSR + VSR \times LC$$

$$\text{Zero error} = 0 + 3 \times 0.1 = 0.3 \text{ mm}$$

**Example 2:**

1 mm marks are present on the main scale of the vernier scale. The total no. of divisions on the vernier scale are 20 which matches the 16 main scale divisions. Calculate the least count of this vernier scale.

**Solution:**

Given:

One main scale division, MSD = 1 mm

20 vernier scale divisions, VSD = 16 main scale divisions, MSD

Therefore, 1 VSD =  $16/20$  MSD = 0.8 mm

The least count, LC = 1 MSD – 1 VSD = 1 – 0.8 = 0.2 mm

***How To Read Vernier Calliper***

1. The first step is to measure nothing through which we can check if the main scale and the vernier scale are aligned with each other.
2. When the main scale reading and the vernier scale reading are at zero, it means there is no zero error.
3. Now, place a ball between the two jaws of the vernier scale.
4. Look at the 0 mark on the vernier scale lining with the main scale. That gives the main scale reading.
5. Next look for the point on the vernier scale which is aligned with the main scale, which gives the vernier scale reading. It is important to note that the readings will most of the time be in decimals.
6. The number before the decimal point is the main scale reading while the number after the decimal point is the vernier scale reading.

## *Parts of a Vernier Calliper*

### 1. Main Scale

- It is a large scale that runs along the body of the vernier calliper. The reading on the main scale could be either in centimetres or millimetres depending on the usage. 1 mm is the lowest main scale division according to the SI units. The main scale is stationary.

### 2. Vernier Scale

- This is the smaller scale that is attached to the main scale such that it moves along the main scale. The movement of the vernier scale is dependent on the opening of the jaws. The main function of the vernier scale is to provide accuracy to the main scale reading by dividing the reading into smaller increments. The vernier scale in a metric calliper can have divisions up to 50 increments such that each division measures 0.02 mm.

### 3. Lower Jaws

- These jaws are considered to be one of the most prominent features of vernier calliper. One of the jaws is fixed and attached to the main scale. While the other jaw is movable and is attached to the vernier scale. These jaws are designed mainly to grip the objects firmly. The main function of the lower jaw is to measure the outer dimensions such as diameter, width and length.

### 4. Upper Jaws

- These jaws are similar to the lower jaws but are smaller than the lower jaws. These jaws are attached to the upper part of the vernier scale. One of the jaws is fixed while the other jaw is movable. The main function of the upper jaw is to measure the inner dimensions of the objects. The jaws are opened till they touch the edges of the objects before taking the reading. The inside diameters of objects such as hollow pipes and jars can be measured using upper jaws.

### 5. Depth Rod

- The depths of the jars can be measured using the depth rod. It is a thin rod located at the end of the main scale. Using a depth rod for measuring is simple. The edge of the main scale is placed on the top surface of the object, then the jaws are slowly opened. The opening of the jaws results in the extension of the depth rod. Until the depth rod reaches the bottom of the object, the jaws need to be opened.

6. Thumb Screw

- This screw is located at the bottom of the vernier scale. The main function of the thumbscrew is to provide grip to the users so that the sliding of the jaws becomes easy.

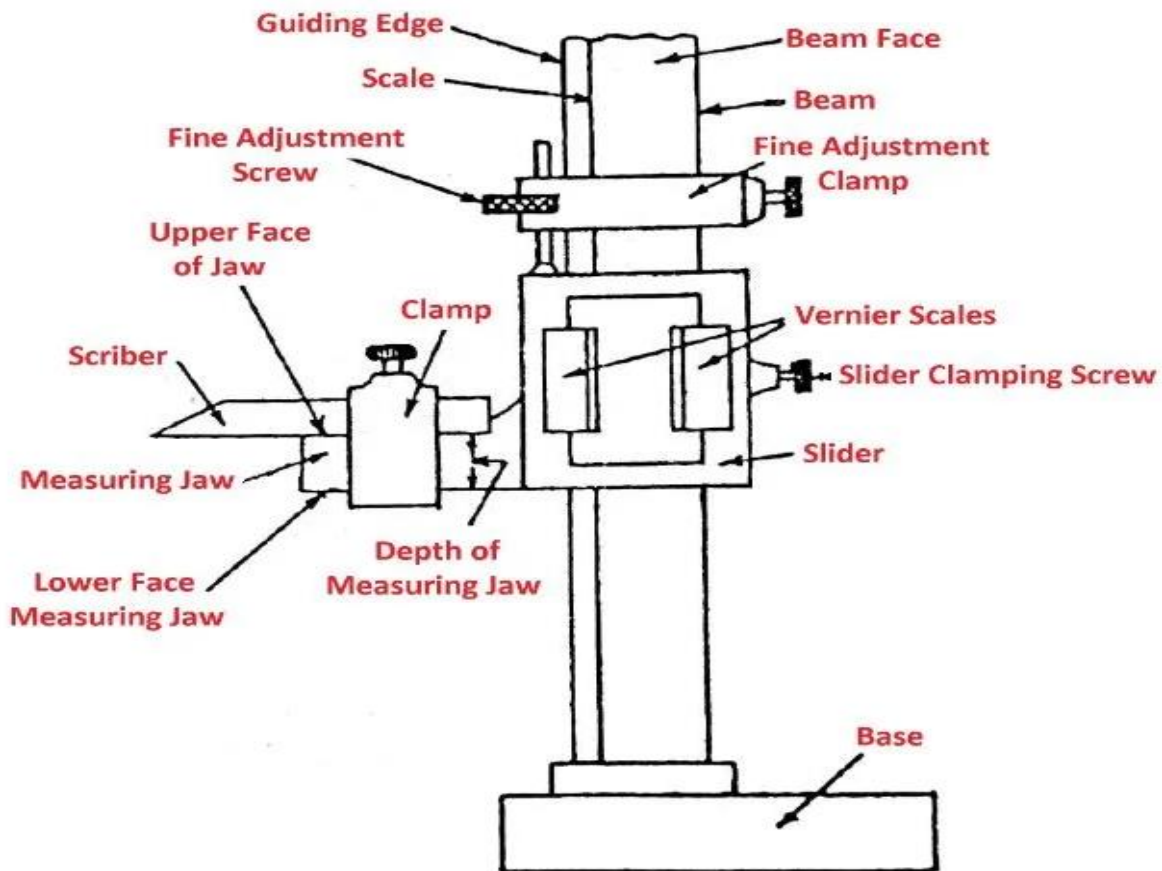
7. Lock Screw

- The main use of the lock screw is to fix the position of the jaws once the object is firmly fixed between the jaws. This also makes it easy to take proper readings.

*Applications of Vernier Callipers*

1. Medical usages
2. Science labs
3. Industries such as steel and aerospace
4. Educational sectors

**3.2.3 Vernier Height Gauge.**



### ***Parts of Vernier Height Gauge:***

Following are the main **parts of vernier height gauge:**

1. Base
2. Beam
3. Measuring jaw and Scriber
4. Graduations
5. Slider

#### **1. Base**

The base is made to high proportions to ensure rigidity and stability of the gauge. The underside of the base is relieved leaving a surface round the outside edge of at least 7mm width and an air gap is provided across the surface to connect the received part with the outside. It is lapped to an accuracy of 0.005mm as measured over the total span of the surface considered.

#### **2. Beam**

To ensure rigidity during use, the cross-section is chosen. The rigidity should be such that an upward force of 1kg applied at the tip of the scriber when the measuring jaw is in its highest position such that there is no change in the parallelism of the jaw with the base of more than 0.005mm / 10mm of projection of the working surface of the scriber.

The guiding edge should be perfectly flat within the tolerances of 0.02, 0.04, 0.06, 0.08mm for measuring a range of 250, 500, 750, 1000mm respectively.

The faces should also be flat within the tolerances of 0.04, 0.06, 0.10, 0.12mm for vernier heights of 250, 500, 700, 1000mm respectively. These faces should be square to base within 0.04mm / 100mm.

#### **3. Measuring Jaw and Scriber**

The projection of the measuring jaw from the edge of the beam should be at least equal to the projection of the base from the beam.

For any position of the slider, the upper and lower gauging surfaces of the measuring jaw should be flat and parallel to the base within 0.008 mm.

The projection of a scribe beyond the jaw should be at least 25mm. Height gauges may have an offset scribe and the scale on the beam so positioned that when the scribe is coplanar with the base, the vernier is at zero position.

#### **4. Graduations**

All graduations on the scale and the vernier should be clearly engraved and the thickness of graduation both on scale and vernier should be identical and should be in between 0.05mm and 0.1mm.

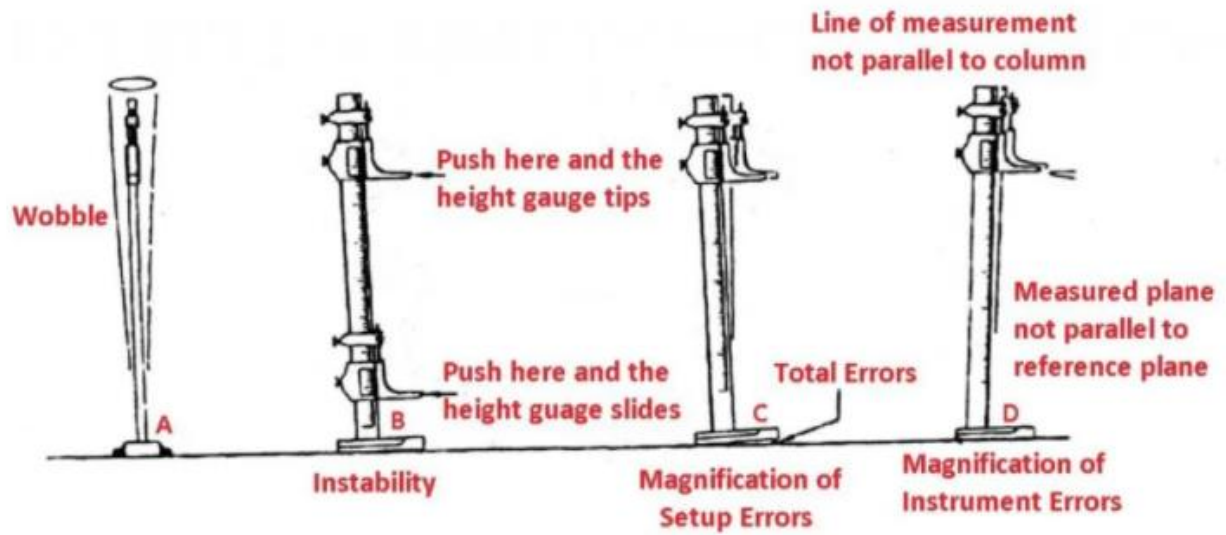
The perpendicular distance between the graduations on scale and graduations on vernier should have a dull finish and the graduation lines blackened in. Even a magnifying lens is provided to facilitate to take readings.

#### **5. Slider**

It should have a good sliding fit along the full working length of the beam. A proper fitting is included to give a precise adjustment of the slider and suitable clamp fitted so that the slider can be effectively clamped to the beam after the final adjustment has been made.

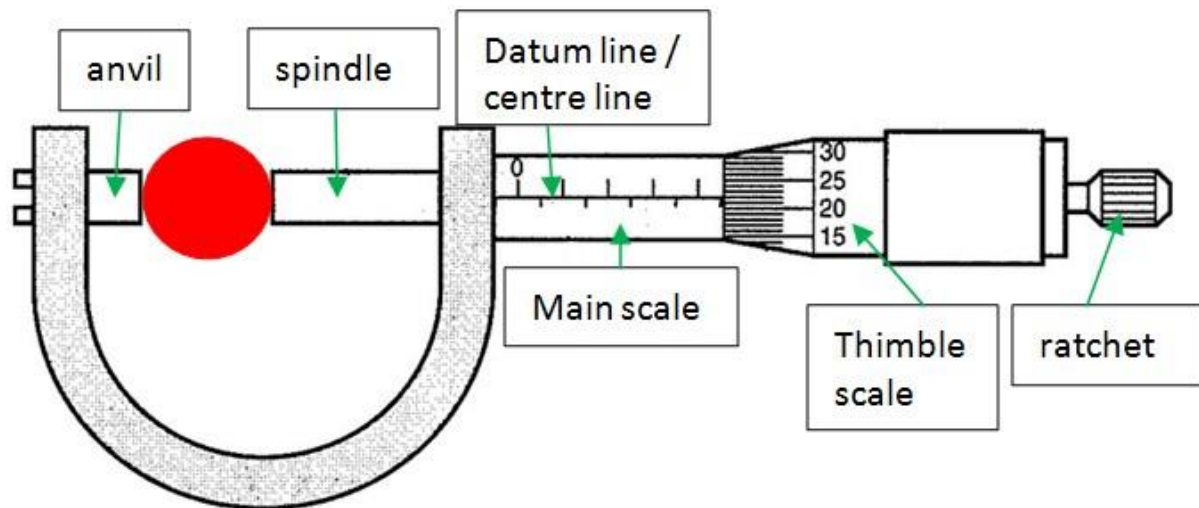
#### ***Errors of Vernier Height Gauge***

- Wobbling
- Instability
- Magnification of setup errors
- Magnification of instrument errors.



Height Gauge Errors

### 3.2.4 Micrometer Screw Gauge



#### *Scales Of Micrometer Screw Gauge:*

A micrometer screw gauge has two scales: the main scale and the thimble scale.

### ***1. Main Scale:***

The main scale of a micrometer is calibrated in mm. The calibrations of the main scale of micrometer screw gauge vary depending on the range of measurement that the micrometer screw gauges are meant to measure. I will not centre on the main scale.

### ***2. Thimble Scale:***

The thimble scale has 50 equal divisions. Each divisions is obtained by dividing 5 by 10. The thimble scale moves a distance of 0.5mm along the main scale when it makes 1 revolution by turning round once. One division on the thimble scale equal to  $0.5/50$  which equal to 0.01mm on the main scale.

### ***Accuracy Of Micrometer Screw Gauge :***

The accuracy of a micrometer screw gauge is 0.01mm or 0.001cm. This means that the smallest distance that a micrometer screw gauge can measure is 0.01mm or 0.001cm.

### ***Accuracy Of An Instruments :***

Accuracy of an instrument is the smallest distance (or value of a particular quantity) that the instrument can measure correctly.

### ***Steps To Follow When Reading A Micrometer Screw Gauge:***

#### ***Step I.***

Read and record the reading of the main scale

#### ***Step II.***

Read and record the reading of the thimble scale at the point where the main scale and the thimble scale coincide.

#### ***Step III.***

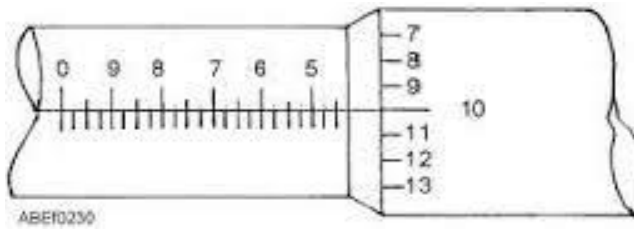
Multiply the reading of the thimble scale by the accuracy of the vernier scale which is 0.01mm

#### ***Step IV.***

Add the result of step III to the main scale reading of step I to get the final answer which is the reading of the micrometer screw gauge.

### ***Worked Examples:***

1. What is the readings of the reading of the micrometer meter screw gauges as shown in the figures below?



Solution:

Reading of main scale. = **4.50 mm**

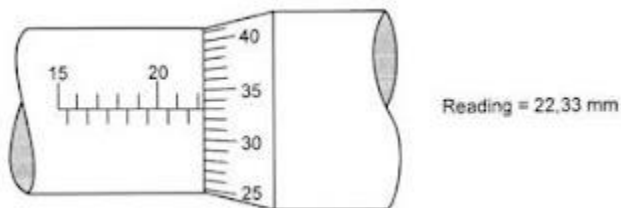
Reading of thimble scale = **10**

Reading of thimble scale x accuracy of screw gauge = **10 x 0.01 = 0.10 mm**

Add the result of step III and step I to get the reading of the micrometer screw gauge.

$$= 4.50 + 0.10 = 4.60 \text{ mm}$$

Reading of micrometer = **4.60 mm**



Solution:

Reading of main scale. = **22.0 mm**

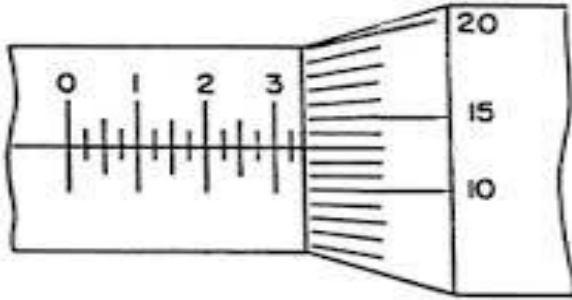
Reading of thimble scale = **33**

Reading of thimble scale x accuracy of screw gauge = **33 x 0.01 = 0.33 mm**

Add the result of step III and step I to get the reading of the micrometer screw gauge.

$$= 22.0 + 0.33 = 22.33 \text{ mm}$$

Reading of micrometer screw gauge = **22.33 mm**



Solution:

Reading of main scale. = **3.25 mm**

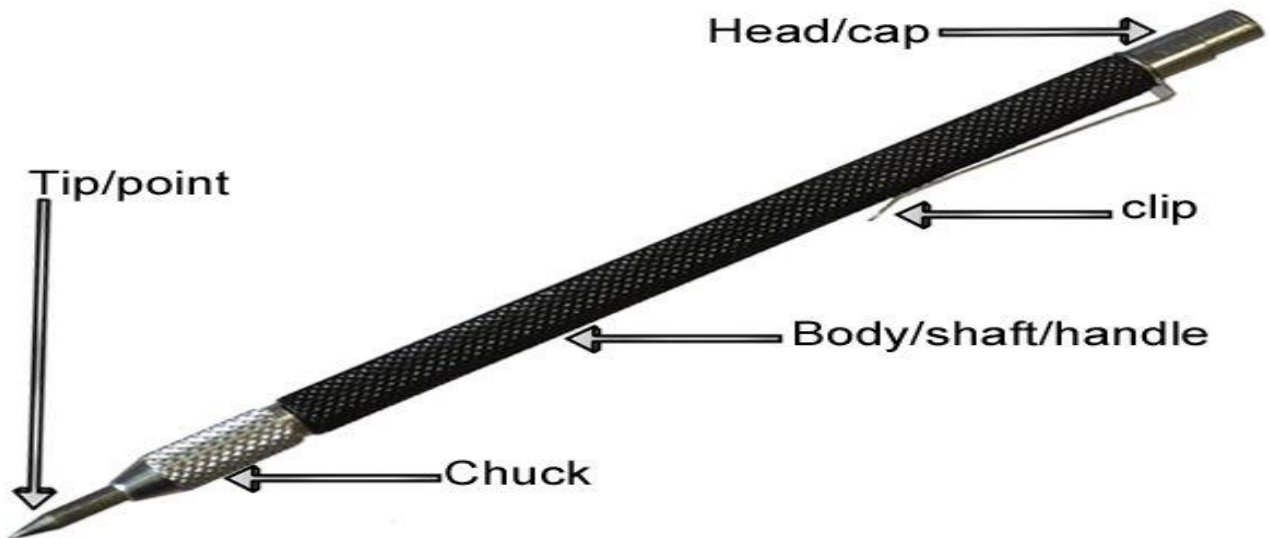
Reading of thimble scale = **13**

Reading of thimble scale x accuracy of screw gauge = **13 x 0.01 = 0.13 mm**

Add the result of step III and step I to get the reading of the micrometer screw gauge. = **3.25 + 0.13 = 3.38 mm**

Reading of the micrometer meter screw gauge = **3.38 mm**

### 3.2.5 Scribes.



Engineer's scribes are used to mark guidelines onto a work piece before it is to be machined. They are most commonly used to mark out metal work pieces due to their advantages over other marking methods on this type of material.

Engineer's scribes have a sharp point that may be made of tool steel, hardened steel or occasionally diamond, enabling them to scribe lines on hard surfaces such as metal

Engineer's scribes are used instead of pens or pencils as scribed lines are shallow scratches that can't be smeared or rubbed off.

Other advantages of scribes over other marking tools are the lines they make are far thinner so they are more accurate and marking ink can be used with scribed lines to make them more visible.

The disadvantages of scribes over other marking tools are that the lines they make can't easily be removed, without grinding or polishing. This means scribes are not always the best tool for marking out an area of the work piece that will be visible in the finished part.

This also means it's very important when using a scribe to make sure your measurements are correct before you scribe the work piece.

### **3.2.6 Scribing Block.**

A scribing block is used to mark lines on a work piece which is against an angle block. The scribing block can be adjusted with a high degree of accuracy and is set from a steel rule. The material is marked by sliding the scribing block so that the scribe makes light contact with the surface of the material.



### **3.2.7 Center Punch**

A centre punch has a hardened tip that is machined and ground to a conical point of  $90^\circ$ . It is used to produce a dent on the surface of material to start a drill hole or as the centre of a circle to be marked with

a pair of dividers. The centre punch is used by placing the point in the correct position and hitting the end of the centre punch with a hammer. A small dent is left in the component.

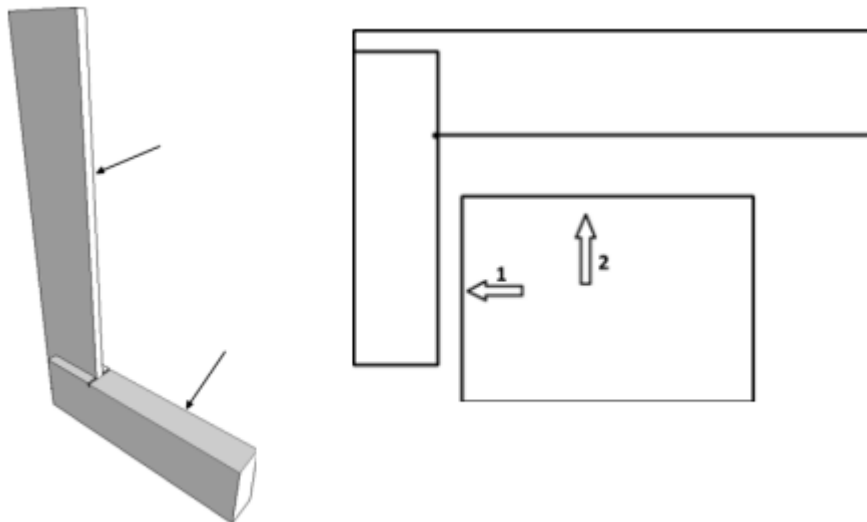


### 3.2.8 Engineer's Square.

The engineer's square is a precision tool used to measure and mark and check 90 degree angles. The engineer's square is made from a sturdy base and a thin blade which is pinned or welded in place. To use the engineer's square to check a piece of material a datum edge must be produced on one edge of the material.

A datum edge is a flat face or straight edge from which all measurements are taken. This prevents cumulative errors being made. All other sides are developed in relation to the datum edge.

The datum edge of the material is held against the stock and slid up to the blade. The engineer's square with the material in position is then held up to a light source. The light will show through in the low spots on the material. The 90 degree angle is achieved by filing the high spots little by little until the material fits closely to the square.

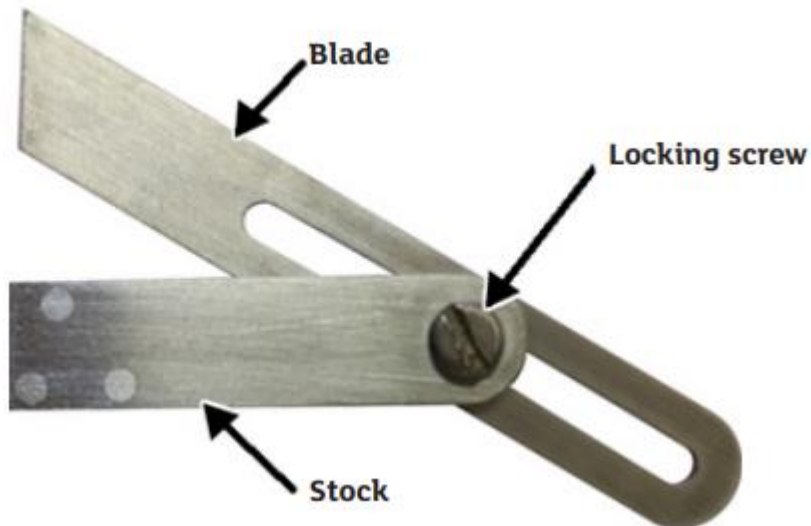


**Engineer's Square.**

### 3.2.9 Sliding Bevel

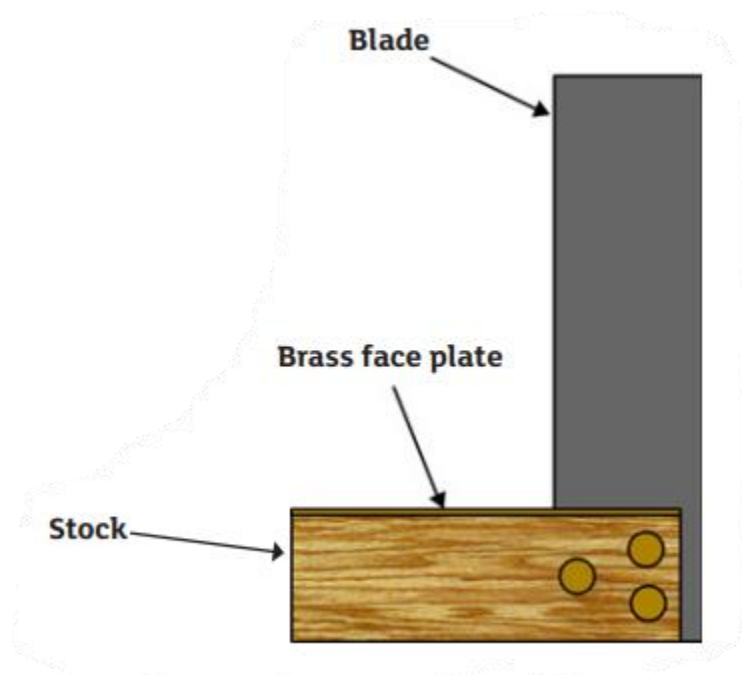
A sliding bevel is a tool which can be set to a given angle to enable a line to be scribed on a piece of metal. It can also be used to duplicate an angle or transfer angles from one place to another. They are

made up of three parts - the stock, the blade and the tightening nut. The tightening nut is used to secure the blade in position.



### 3.2.10 Try Square

The try square is a woodworking tool used to mark lines at 90 degrees to an edge or to check the edges of material to see how square it is. The try square has a hard wood stock with a brass face to protect it from wear. The blade is made from hardened and tempered steel so that it is hard wearing and flexible.



### **3.2.11 Odd Leg Callipers**

Odd-leg callipers are used to scribe a line parallel to the edge of a piece of metal. The locating leg is run along the edge and the scriber point marks the surface of the material.

The odd-leg callipers shown have a renewable scriber that can be adjusted and replaced when necessary.

Odd-leg callipers are set using a steel rule, the locating leg is placed on the end of the rule and the point is moved to the correct measurement on the rule edge.



### **3.2.12 Spring Dividers**

Spring dividers are used to mark circles on material and for geometric development such as bisecting angles.



## **3.3 Workshop Hand Tools**

### **3.3.1: Vices.**

Vice is a job holding tool, which is used to hold the job firmly in the workshop. The Vice is used to tightly hold the job while performing operations in workshops like a filing, cutting, drilling, tapping, dyeing, etc.

There are the following types of vices used in the workshop:

- Bench Vice

- Pipe Vice
- Tool Makers Vice
- Hand Vice
- Leg Vice
- Drill vice
- Pin Vice

**a. Bench Vice**

This is a job holding device that is often used to hold the tasks while performing operations such as sawing, filing, chipping, tapping, external threading, etc. It is fitted above the bench.

There are two steel jaws on this vice that are hardened and have grooves on them. Its height is kept equal to the elbow of the artisan.

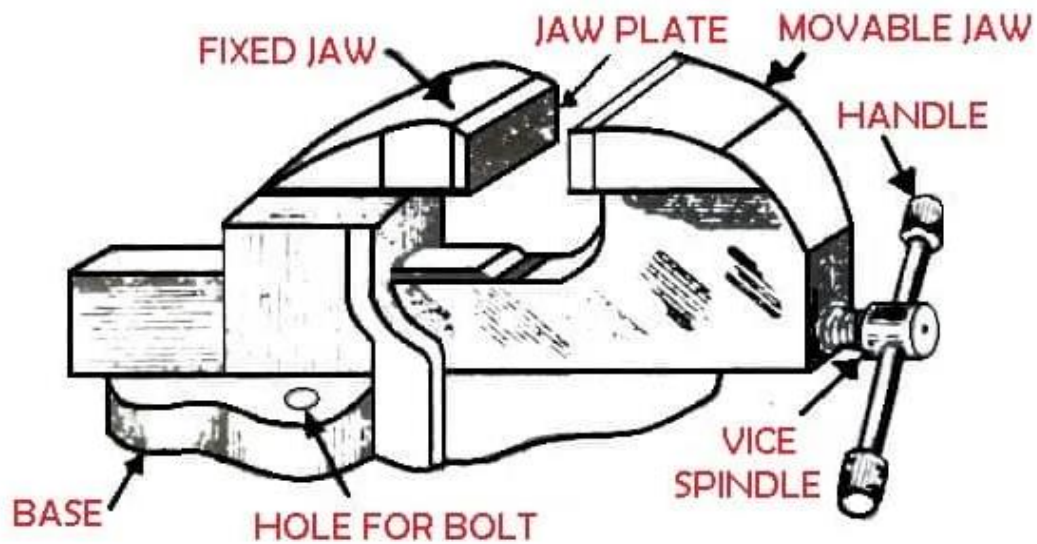
Its fixed jaw remains fixed and only the movable jaw moves and tightens the work when the spindle is tightened.

To hold the finish works, regular jaws (jaws) should be coated with aluminum, brass, or copper to prevent the finished surface of the work from deteriorating. It is also called machine vice when it is fitted with a machine.

*Bench vice Parts and Functions*

There are following parts are attached to the bench vice:

- Fixed Jaw
- Movable Jaw
- Jaw Plates
- Spindle
- Handle
- Box Nut



### **Bench Vice Parts**

#### *Fixed Jaw:*

Fixed Jaw is always fixed in the bench with the help of a nut and bolt. A fixed jaw is made with grey cast iron.

#### *Movable Jaw:*

Movable Jaw moves back and forth according to the size of the job. Movable Jaw is also made with grey cast iron.

#### *Jaw plates:*

The jaw has a plate inside, which is fixed by a screw and is known as a Jaw plate. These plates are fitted with cross-cuts, which create a grip on the job. For making these plates carbon steel's metal is used.

#### *Spindle:*

The movable Jaw has to consist of a spindle, which is made of mild steel. The movable jaw moves back and forth only when this spindle rotates.

### *Handle:*

Handle is fitted with the spindle and then rotates the handle clockwise and anticlockwise direction then the spindle moves forward and backward.

The handle is made of mild steel.

### *Box Nut:*

The nut that the spindle passes through is called the box nut as well as the guide nut.

Box nut always fits in the fixed jaw. It is made of cast iron or gun metal.

## **Points to be Noted While Fixing a Bench Vice**

1. The height of the vice should be one meter from the shop floor to the top of the vice or equal to the artisan's elbow.
2. It is advisable to fix the bench vice with bolts, nuts, and washers above the top of the bench as it provides good support and strength.
3. It should be at the level and parallel to the vice job work bench and shop floor. If it is not fixed to level then the material will rub more than one side on the job.
4. Its fixed job should be slightly out of the end of the work bench.
5. The vice should be firmly fixed. If it is not held firmly, it will vibrate, affecting the surface finish and precision.

### **b. Pipe Vice**

This type of vice is often used for round shape work and C clamping of pipes, especially plumbing and locksmith works.

On it, the 'V-shaped groove's jaw is cut, which allows the pipes and cylindrical bars to be well gripped while performing cutting, threading, etc.

### **c. Tool Makers Vice**

This type of vice is used to hold the difficult job which is in a small size while filing and machining.

It can be swiveled to set the work at any angle.

#### **d. Hand Vice**

This vice is used to grip screws, rivets, nails, and other similar materials that are too small to hold in the bench vice.

Sometimes it is also used to hold thin plates while drilling.

#### **e. Leg Vice**

This type of vice is used to perform heavy and rough types of work such as bending, forging, and chiseling and it can bear heavy work.

#### **f. Drill vice**

This is a strong vice with a movable joint. It can be moved forward and backward by rolling the handle of the movable jaw.

This vice is used while drilling on small pieces.

#### **g. Pin Vice**

This vice is used to hold a small diameter of jobs such as pins, needles, etc.

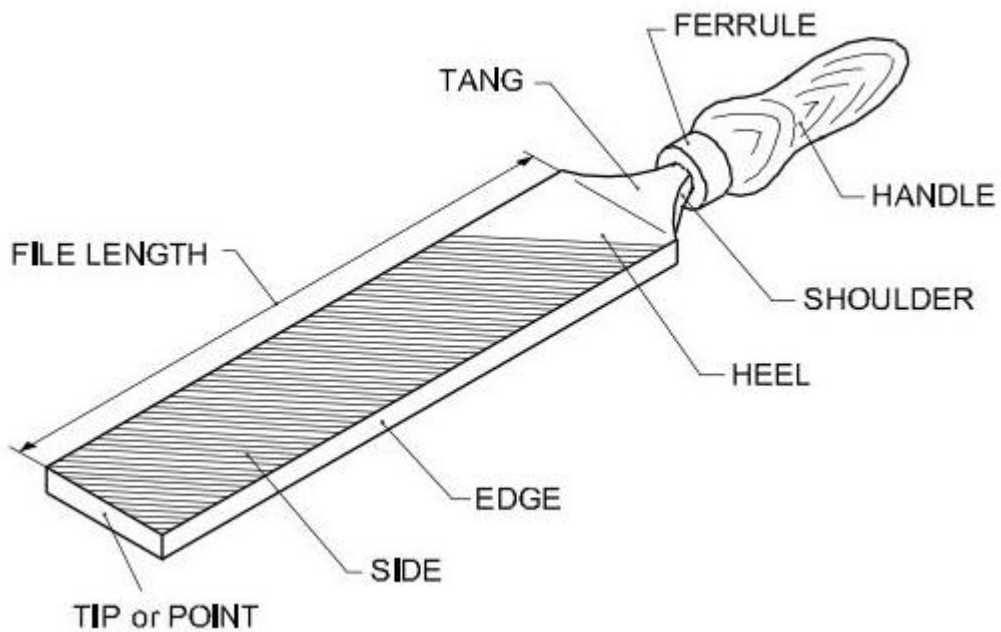
### **Care and Maintenance of Vices**

- The sliding back should not be used as an anvil. The vice should be tightened only by its handle. Hammer should not be used to obtain more leverage.
- From time to time, the vice should be cleaned and applied to it and check its looseness. If the jaws become loose, they should be replaced.
- When the vice is not in use, it should be kept loose.

### 3.3.2 Files.



### Parts of a file.



### Different Types of File Tools

#### A) Classification According To The Shape

The file tools are classified according to various types. One amongst this is the classification according to the shapes:

### **1. Flat File:**

A flat file is referred to as a file which is of a rectangular cross-section in shape. This instrument is designed in a slightly different way by tapering both the width and thickness of the file. Double cut teeth are cut on the face whereas the simple-cut teeth are cut on the edges. These instruments are the one which are used to reduce the flat surfaces by filing and finishing the work piece.

### **2. Round File:**

As the name clearly tells, these are the types of file which is found having a round section. This type of files are used for the purpose of rubbing or finishing the keyholes of a small diameter.

### **3. Half-Round File:**

Half round files are the files which is found on the side and is curved on the other side. On the other hand the double cut dents are cut on it like a round file which is then tapered. These types of mechanical instruments are mainly used to repair the damaged hole and to also set them in order again.

### **4. Triangular File:**

The name clearly depicts the shape of such types of files. The files slots are found having angles of 60 degrees. In order to complete filing of V slots job, the square and rectangular jobs ranging from 60°-90° angle are mostly done using this file. This type of file is also known as three square files.

### **5. Square File:**

These types of files are in the shape of a square and are found being tapered. The slots of filing in a rectangular, square groove and key-way is done using these types of file.

### **6. Hand File:**

A hand file is quite similar to the flat file which is mostly used for filing the internal right angle side of a job. These types of hand files are also known as the safe edge file.

## **7. Knife-Edge File:**

Knife edge files are used at places where there is a requirement of a sharp file. The shape of this type of mechanical instrument is like the edge of a knife. The thin edge is usually at an angle of  $10^\circ$ . These are also used for filing the small grooves and slots which are found having an angle less than  $60^\circ$ . Knife-edge files are generally used in the lock industry for making the keys.

## **B) Classification According To Grade**

The files are also classified according to the type of grade. Here are some of the most common types of files which are segregated according to the grade. Scroll down to know more about these types of files:

### **1. Rough File:**

These are the files which are found having teeth of the bigger size and less in number. The round files are found having their application in cutting the soft materials as its cutting is quite rough due to which, it cannot be used for the hard metals.

### **2. Second Cut File:**

A second cut file is referred to as a file which is found having the medium grade. For the purpose of filling, this type of file is most commonly used in order to bring the job in a proper size. Comparing these types of files with the bastard file, filing is found to be done with this file in order to make the surface plain.

### **3. Smooth File:**

Smooth file is used at endless sites where the ultimate target is to get a smooth surface. This types of files are used to make the surface quite plain and other than this it is additionally used for making a job of accurate size by filing.

### **4. Dead Smooth File:**

The dead smooth file is designed in such a way in which its teeth are found to be very close to each other and rubs off the metal in very little quantity. These mechanical instruments are used for bringing the shine on the job once the finishing has been done successfully.

## **C) Classification of Files On The Basis of Cut**

The files are also classified according to the basis of cut. Here are some of the most common types of files which are segregated according to the type of cut. Scroll down to know more about these types of files:

### **1. Single Cut File:**

A single cut file is referred to as that mechanical tool which is found having parallel lines of teeth that run diagonally across its face and that too in one direction only. The metal surface is rubbed nicely in the little quantity and therefore the surface becomes smooth. Therefore, these are the devices which are used for the hard metals as well as for finishing.

### **2. Double-Cut File:**

Double cut file is referred to as that file which has two rows of teeth crossing each other at a particular angle of 40°- 45° degrees and the other row having an angle of 70°- 80°. This is set in such a way due to the double teeth. This file is responsible for cutting the metal quickly but on the other side it cannot make the surface that smooth. These types of files are also referred to as a coarse type file having an angle of 30° to 35° in one row and 80° to 87° angle in the other row.

### **3. Curved Cut File:**

A curved cut file is also known as Vixen file which is mostly used for filing of the wide surfaces of soft metal like aluminium, zinc, copper and brass.

### **4. Spiral Cut File:**

This types of files has teeth, which are cut in round or semi-round files. The shape of the teeth in a spiral cut file is like that of threads.

### **5. Rasp Cut File:**

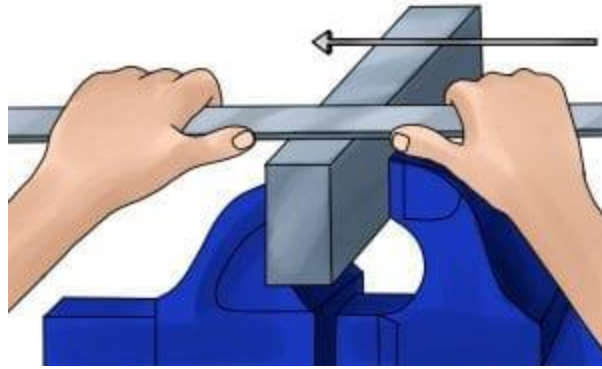
Rasp cut file is a type of file which has special thick teeth. These are the teeth which are of triangular shape and also are found to be in a bulging state. These are the files which are used for working in woods, plastic, fiber, hard rubber and horns and hoofs of animals.

### **Techniques of filing**

There are three commonly used filing techniques that are widely used, these are: cross filing, draw filing and lathe filing.

#### ***Cross filing:***

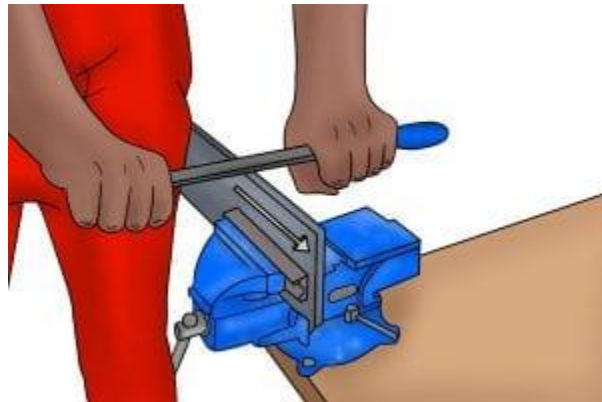
Also called straightforward filing, this technique involves pushing the file across the edge of the material. It can be used for finishing, shaping or sharpening. This is the most commonly used filing technique. It's easy to do, but difficult to master completely.



**Cross Filing.**

### ***Draw filing:***

This technique is a little more unusual and involves holding a file at each end and using it in a similar way to sandpaper. This technique is only used for finishing, and only with single-cut files.



**Draw Filing**

### ***Lathe filing:***

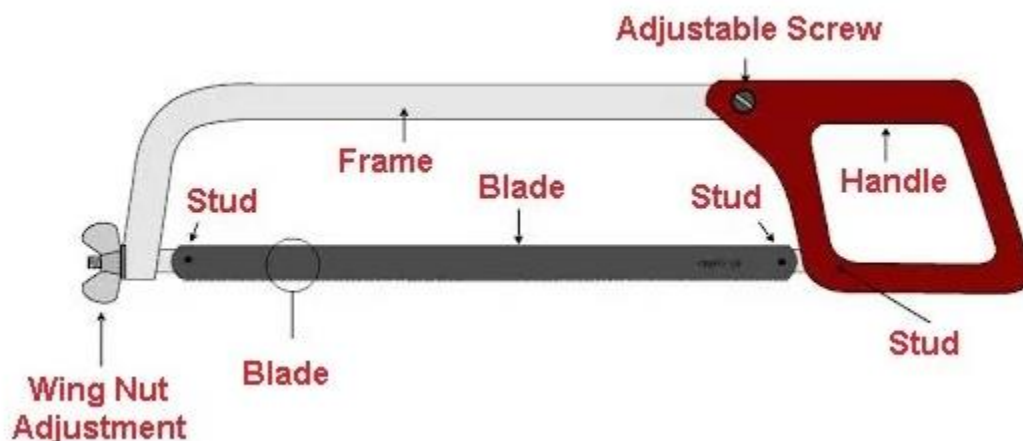
Lathe filing is used to smooth and shape cylindrical pieces of material, such as wooden chair legs. This is a tricky technique that involves mounting your workpiece in a lathe, which will rotate it when activated. The lathe must be spun faster than usual to ensure maximum filing consistency. The lathe filing technique is otherwise similar to cross filing.

### **Care of files.**

1. A new file should be broken in by using it first on brass, bronze, or smooth iron.
2. Never use a new file to remove the fins or scales on cast iron.

3. Do not use a new file on a narrow surface such as sheet metal, because the narrow edge of the metal is likely to break off the sharp points on the file teeth.
4. After using a new file, the teeth will clog up with metal filings.
5. Using a clogged file will scratch the work. This condition is called pinning.
6. One way to help prevent pinning is by rubbing chalk between the teeth before filing.
7. The best method to keep the file clean is to use a file scorer and file cleaner brush.
8. When cleaning a file with a file scorer (1), use a pulling motion, holding the file scorer blade parallel to the rows of teeth.
9. Finish cleaning by brushing the file parallel to the rows of teeth, with the file cleaner brush.
10. Do not throw files into a drawer or toolbox where they can rub against each other or against other tools. Store them in separate holders such as clips, straps, or in holes cut in a block of wood.
11. Clean files often.
12. Never strike the file against a vice or other object to remove filings. Use the file cleaner brush.
13. Never store files with lubricants or rust-preventive compounds on them. Wrap each file in a water-proofed barrier wrapping paper and place the files in racks or boxes so that the faces or edges of the files will not touch each other.
14. Never use a file without a securely attached handle.
15. Do not use files for any other use except filing.
16. Do not oil files. This will cause the file to slide across the work, preventing fast cutting.

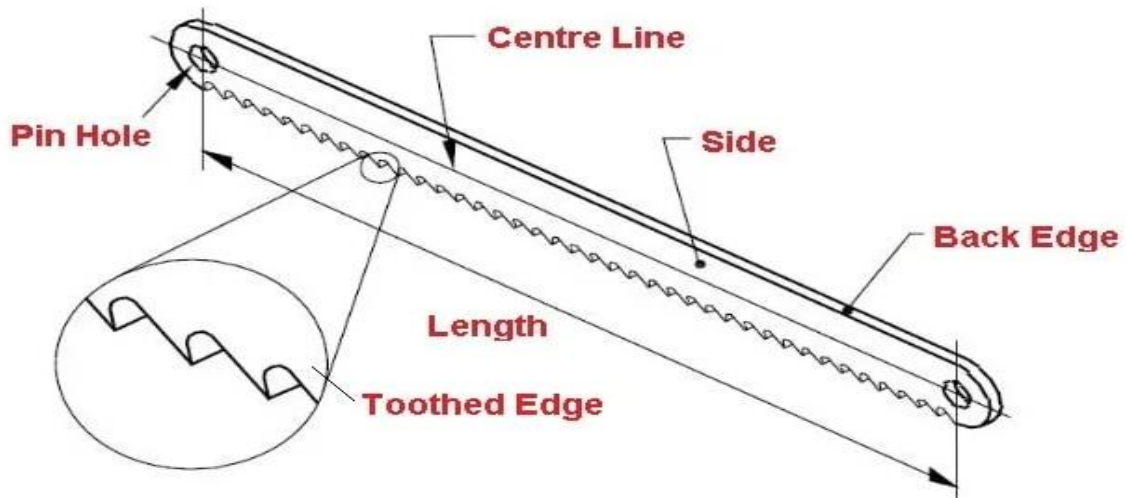
### 3.3.3 Hack Saws.



A hacksaw is a hand-powered, small-toothed saw used for cutting metal pipes, rods, brackets, etc. Hacksaws can also cut through plastic.

The hacksaw has a U-shaped frame and a handle at one end. Hacksaws have small pins at each end of the frame that receive a blade. A tensioner nut or knob is then used to extend the length of the frame, which puts tension on the blade and locks it in place. The blade can be installed to cut on either the push or pull stroke; cutting on the push stroke is more common.

### **Hacksaw Blade**



On the basis of metal of the job, different types of hacksaw blades are used in a hacksaw. These are made of tungsten steel, high-speed steel and they are hardened and tempered. Their classification depends on three points:

- Size of the blade.
- The number of dents cut on the blade per inch.
- Nature of the blade.

Length of hacksaw blade is generally 8", 10" or 12". Dents of four different grades are cut on them.

### ***Types of Hacksaw Blades***

Following are the main types of hacksaw blades:

- i. Course Grade Hacksaw Blade
- ii. Medium Grade Hacksaw Blade
- iii. Fine Grade Hacksaw Blade
- iv. Superfine Grade Hacksaw Blade
- v. Ail Hard Blade

### ***1. Course Grade Hacksaw Blade***

Hacksaw blade of this grade is used for cutting thickness of mild steel, copper, aluminium and brass etc. It contains 14 to 18 teeth per inch.

### ***2. Medium Grade Hacksaw Blade***

Hacksaw blade of this type is used for cutting all kinds of metals such as cast iron, tool steel, aluminium, brass, high carbon steel etc. From 20 to 24 teeth per inch are cut in this hacksaw blade.

### ***3. Fine Grade Hacksaw Blade***

This type of hacksaw blade is mainly used to cut thin pipes, sheets, tubes etc. It has 24 to 30 dents per inch.

### ***4. Superfine Grade Hacksaw Blade***

For cutting extraordinary solid metals and thin metal sheets, thin type of hacksaw blade is used. There are 30 to 32 dents per inch in this type of hacksaw blade.

In all the hacksaw blades of various grades mentioned above, teeth are cut on one or both the edges. These blades are hardened in two different processes and on these depend their nature.

### ***5. Ail Hard Blade***

Blades of this nature are hardened and tempered only except the ends having holes. These are used for cutting articles cast iron or mould iron etc.

### ***6. Flexible Blade***

In blades of this nature only the cutting teeth and nearby part it hardened and tempered. But this process they become elastic and there is less risk of their being broken in the event of a shock. These blades are used for cutting thin sheets, pipes, curves etc.

### **Precautions of Using Hacksaw**

Following are the precautions of using hacksaw:

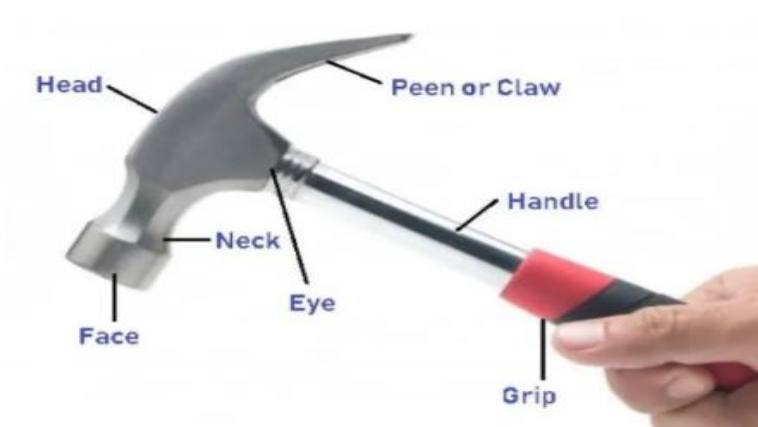
1. Hacksaw blade should be fitted on the frame very carefully. It should not be very tight nor very loose.
2. The job which is to be cut should not be held in a vice much high otherwise there would be vibrations in it.

3. While cutting thin metal sheet, packing of wood, plastic or any other appropriate material should be used in its front and back.
4. Hacksaw blade should not be allowed to become slanting while using a hacksaw. If it becomes slanting, there are chances that it may break.
5. If the blade starts cutting in a slanting manner we should start a fresh cut. Operating a hacksaw in an old cut may break it.
6. If a blade gets broken while working, then we should replace it with a blade which has been used almost for the same period rather than using a brand new blade. The new blade can break if it is operated in that old slot.
7. If necessary, water should be used as a coolant.
8. After using a hacksaw either its blade should be taken out or it must be made loose.

### 3.3.4 Hammers.

#### 1. Hand Hammer

These hammers are made of cast steel or carbon steel. Their pan and face are hardened and tempered. The middle body is kept soft. On one end of the body, face and pan are made.



An oval-shaped hole is made in the body in which the handle is fitted by using a wedge. Because of the wedge, the hole is somewhat enlarged and there is no risk of handle becoming loose and coming out. The length of the hammer depends on its weight. On heavy hammers, long handles are used. Contrarily on the lightweight hammers, shorter handle are used. In hand hammers, the handle of 8 to 12 is used. According to I. S. 841-1957, the handles used for marking etc. have 0.11 to 0.33 Kg weight.

## **2. Ball Peen Hammer**

These types of hammers are most widely used in the workshops. On one end of this ball peen hammer, a plain face is made and on the other end, a peen of 3/4 like a round ball is made.

It is used for setting the rivet. It is also used to strike blows on a metal sheet up to a certain depth. This type of hammer has been shown in the figure. Its weight is between 0.11 to 0.91 kg.

## **3. Sledge Hammer**

These are mostly used in blacksmithy for straightening round rods, iron bars, angle iron, channel, or flat iron.

Its shape is similar to a double face hammer. These are used for heavy jobs their weight is more. Their weight is from 4 Kg to 10 Kg. It has been illustrated in the figure.

## **4. Claw Hammer**

These are special types of hammers. On one end of this hammer, a round face is made and on the other end, its peen is inclined towards the handle.

In its center, a slot is cut, with whose help nails, etc. can be easily extracted (taken out). This hammer is generally used by the carpenters in the carpentry trade.

## **5. Club Hammer**

If compared to a drilling hammer or lump hammer, the tool has a small, double-faced head that is similar to a sledgehammer. In commercial work, the club hammer is useful for making steel chisels and masonry heads, as well as light leveling work.

## **6. Dead Blow Hammer**

The head of this type of hammers are designed for minimum recoil and soft blows. It usually consists of a solid rubber or plastic head, or a semi-hollow head filled with sand or lead shot.

They are used in everything from woodworking to automotive applications, where they help destroy parts, fix small dents, and knock wood together or apart without marring the surface.

## **7. Tack Hammer**

This unique hammer consists of two long claws like heads, one of which is magnetized.

It is also known as an upholstery hammer and it is used to hold a tack for placement using a magnetic end, then controlling a tack that is placed using a non-magnetized end.

## **8. Rubber Mallet**

It is the most common types of hammers, it has a rubber head that allows a soft bang. They are used on sheet metal, woodworking, and filling. A rubber mallet is soft enough to force it without damaging the plasterboard.

## **9. Framing Hammer**

It is exactly similar to a claw hammer. The framing hammer is consists of a straight claw and a waist head. Its primary function is to assemble the house frames. That's why it is called a framing hammer.

### **3.3.5 Chisels**

Chisel is used to cut flat, round or angle iron and thick metal sheets. It is also used to remove the unwanted metal from the surface of a job by cutting it in bits and small pieces. This act is known as chipping.

The cutting done by a chisel is rough. Therefore, there is need for finishing after chipping done by the chisel. It saves time. Chisels are used both on hot and cold metals. As such chisels have been divided into two categories.

- Hot chisel
- Cold Chisel

#### **1. Hot Chisel**

Hot chisel is used for cutting hot metals in blacksmith's workshop. There is a hole in a chisel in which a wooden handle is fixed. Their cutting edge is made at an angle of 30°. While using this part, it is frequently dipped into water for making it cold so that its edges remain intact.

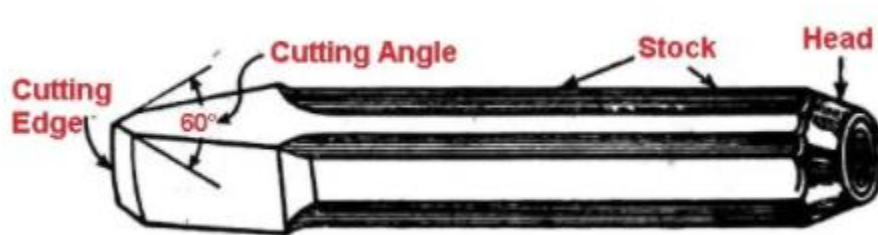
#### **2. Cold Chisel**

Cold chisels are generally used in sheet metal and fitter trade workshops. With cold chisel cutting or chipping of metal can be done when these metals are in cold condition.

This is available in 4 sides, 6 sides or 8 sides. These are made of high carbon steel, which contains 0.75% to 1.00% of carbon. Generally, chisel, of 150 mm length is used. Practically, chisels measurement is known from the width of chisels cutting edge.

### Parts of a Chisel

Following are the different parts of a chisel:



- Head
- Body
- Forging angle
- Cutting edge
- Cutting angle
- Parts of a Chisel

#### 1. Head

The topmost part of a chisel is called “Head”. It is a bit sunk in the middle so that the blow of hammer strikes at the centre of the chisel. Thus, because of repeated blows, its head becomes mushroom.

In this case, the chisel’s head should be set right by grinding. While making the head, the upper part of the body should be 10° to 20°.

#### 2. Body

That part of a chisel from which we hold it is called the body or stock. It is made of four, six or eight sides so that it is easy to hold. The body is made somewhat flat from the bottom.

#### 3. Forging Angle

Some part of the flat position below a chisels body is tapered. This angle of taper is called forging angle. It is also known as Draw Angle.

#### **4. Cutting Edge**

That part of chisel that performs the function of cutting is called the cutting edge. Its width is taken as chisels measurement.

#### **5. Cutting Angle**

The angle at which a cutting edge of chisel is grinded is known as its cutting angle. For cutting hard metal, the cutting angle is more and for cutting soft metals the cutting angle is less. While grinding chisels for cutting various kinds of metals their angles should be as under:

Mild steel – 55 °

Cast iron – 60 °

Tool steel – 65 ° to 70 °

Copper – 45 °

Aluminum – 30 °

Brass – 50 °

#### **Types of Chisels**

Following are the different types of chisel:

- Flat chisel
- Cross cut chisel
- Side cut chisel
- Round Nose Chisel
- Diamond point chisel
- Cow mouth chisel

##### *1. Flat Chisel:*

In these types of chisel, It is an all-metal chisel used for obtaining a flat surface on metal by chipping. This chisel is used to cut wires, thin sheets and round rods etc.

The edge of this chisel is in “V” shape and is flat, which is raised from the centre. Because of this projected parts, it does not get stuck into the cut surface, while chipping.

## *2. Cross Cut Chisel*

It is mainly used to cut square slots and channels. Keyway on a shaft is made with this chisel. Its cutting edge is from 3 mm to 12 mm in width.

In order to ensure that this chisel does not get stuck into the grooves and slits while using it in the grooves and slits, the part behind its edge is made comparatively thin.

## *3. Side Cut Chisel*

Where other types of chisel cannot be used easily, side cut chisels are used. The keyway and cotter way is cleaned with this chisel.

It is almost similar to the flat chisel but the part which performs the function of cutting is turned to one side. It is turned at an angle and then forged. Its cutting angle is generally at and forging angle at an angle.

## *4. Round Nose Chisel*

Its edge is round. It is used for making an oil groove in a bearing and for cutting slits at corners. Its forging angle is at and cutting angle is of  $35^\circ$  to  $40^\circ$ . In such jobs where the drill is dislocated at the time of drilling and some substance is left, the leftover metal is set right with this chisel.

## *5. Diamond Point Chisel*

This is made of good quality steel. Its shape is square and it is tapered. Its edge is pointed and of the shape of a diamond.

On the basis of its square ends, its measurement is determined. Square corners and triangle corners are cleaned with it. We can make a groove in plain surface with this chisel.

## *6. Cow Mouth Chisel*

In these types of chisel, Its shape is like that of the broad mouth of a cow. That is why it is known as cow mouth chisel. Edges of the protruding parts of plain metal and rivet heads and big round holes are made with it. Its forging angle is at an angle.

## Methods of Using Chisel

Chisel is used for cutting and chipping a thin metal sheet, plate, round rod and such other material. The following points should be kept in mind while using a chisel:

1. Accurate marking should be done on the metal to be cut.
2. Always hold the chisel properly with your left hand and the hammer in your right hand.
3. Set the chisel properly on the marked line then strike the hammer on its head. Before striking the second blow on the chisel, it should be set again.
4. While cutting with a chisel we should concentrate on its cutting edge.
5. Strike the hammer blow at the centre of the head of the chisel.

## Precautions of Using Chisel

1. At the time of chipping, we must always use safety goggles.
2. Keep your face towards the wall, while chipping.
3. If someone is working in your front, you should fix chipping guard at the rear of the vice so that chips do not hit him.
4. The mushroom head chisel should never be used for chipping.
5. There should not be any greasy substance on the chisel head and face of the hammer being used for chipping.
6. An extraordinarily long chisel should not be used for chipping.
7. While chipping we should keep on applying grease on the edge of the chisel.

### 3.3.6 Snips

Snips are made in various shapes and sizes for various tasks. The handle can be like those on scissors with finger and thumb holes or like plier handles. Models are available for cutting in straight lines, in curves to the left or curves to the right.

Universal snips can cut in both straight and wide curves.

Straight snips and duckbill snips (flat blade, "perpendicular" to the handle, with pointed tips) are designed to cut in straight lines; some duckbill snips are designed for cutting curved lines.

Hawk's bill snips (with crescent-shaped jaws) are used for cutting tight circles.

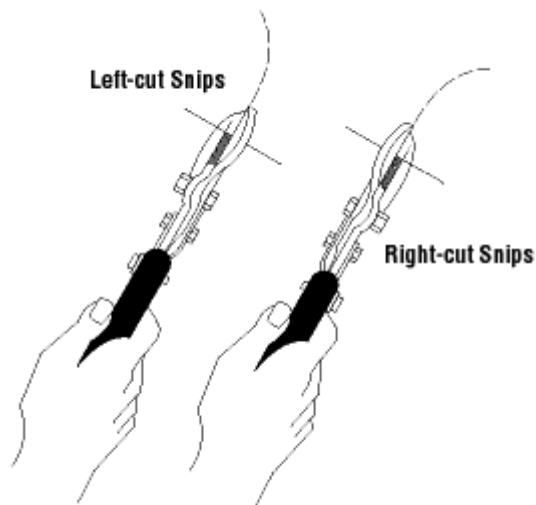
Aviation snips have compound leverage that reduces the effort required for cutting.

Offset snips have jaws that are set at an angle from the handle.

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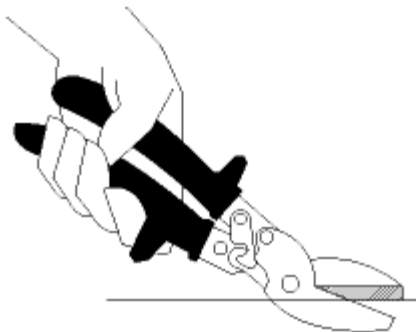
1. Select the right size and type of snips for the job; check the manufacturer's specifications about the intended use of the snips (e.g., type of cut – straight, wide curve, tight curve, right or left, and maximum thickness and kind of metal or other material that can be cut).
2. Only use snips that are sharp and in good condition.
3. Wear safety glasses or goggles, or a face shield (with safety glasses or goggles) and protective gloves when working with snips. Small pieces of metal may go flying in the air and the cut edges of metal are sharp.

**Left cut snips** are for making cuts to the left and straight cuts.



**Right cut snips** are for making straight cuts and cuts to the right.

**Straight cut snips** (not shown) are for making straight cuts and shallow cuts to the right or left.



**Offset snips** permit you to keep your hands safely above the cut while cutting directly through the centre of a large sheet.

### **Precautions when using snips.**

- Use snips for cutting soft metal only. Hard or hardened metal should be cut with cutting tools designed for that purpose.
- Use ordinary hand pressure for cutting. If extra force is needed, use a larger tool.
- Cut so that the waste is on the right if you are right-handed or on the left if you are left-handed.
- Avoid springing the blades. This results from trying to cut metal that is too thick or heavy for the snips you are using.
- Keep the nut and the pivot bolt properly adjusted at all times.
- Oil the pivot bolt on the snips occasionally.
- Use the locking clip (if available) to keep the snips closed when not in use.

### **What should I avoid doing?**

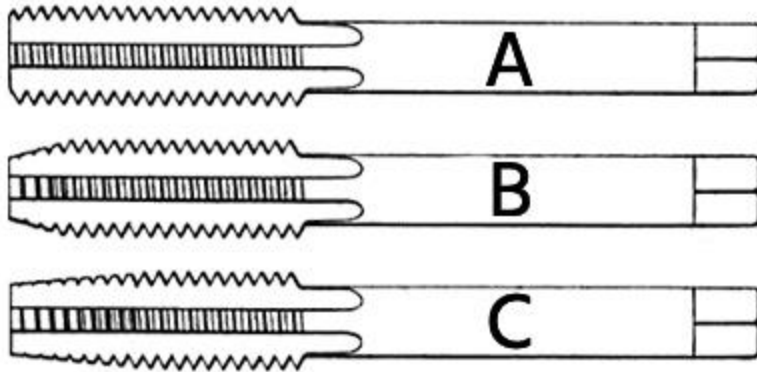
- Do not try to cut sharp curves with straight cut snips.
- Do not cut sheet metal thicker than the manufacturer's recommended upper limit (e.g., cuts up to 16 gauge cold rolled steel or 18 gauge stainless steel).
- Do not extend the length of handles to gain greater leverage.
- Do not hammer or use your foot to exert extra pressure on the cutting edges.
- Do not use cushion grip handles for tasks requiring insulated handles. They are for comfort primarily and not for protection against electric shocks.
- Do not attempt to resharpen snips in a sharpening device designed for scissors, garden tools or cutlery.

### **3.3.7 Taps and Dies**

A tap is a threaded tool that cuts or forms threads in the female portion of a mating pair. Therefore, a tap will create threads in the inside of a hole. On the other hand, a die is a threaded tool that cuts or forms threads in the male portion of a mating pair. Therefore, a die will create threads on a cylindrical rods surface to create a screw or bolt. Both a tap and a die create new threads or repair damaged threads.

#### **The Tap**

Taps thread the inside surface of a hole to create components like nuts or holes (blind or through) to screw in a screw or bolt. There are three main types of taps. The plug, second, and taper (also known as bottoming, plug, and taper in the U.S.). The image below illustrates the three types:



## How to use a tap

### *Prepare the hole:*

1. This is the first step of tapping. It is the formation of a hole, usually by drilling, to a diameter smaller than the tap's outer diameter. This diameter is called the tap drill size.
2. The drill bit to be used for the hole diameter is listed in the [drill and tap chart](#), usually inside the tap and die set. It is also available in machine shops.
3. Drill the hole, either a blind hole or through-hole.
4. Ensure removal of all chips from the hole.
5. Select tap and ratchet: Use the chart again to select the right tap size for your project. Remember, there are different types of taps. You may have to start with a tapered tap before finishing with a plug tap.
6. Depending on the tap size, use the appropriate ratchet. There are typically two sizes. Using the larger ratchet for a small tap may lead to an excessive force that can break the tap.

### *Create the threads (hand tap):*

1. Fasten down the material to be threaded with a vice or clamp.
2. Insert the tap, ensure it is centered and aligned, and turn in the clockwise direction making two complete rotations. Then turn anticlockwise for half a cycle. Repeat this process until complete threading. This style of tapping prevents broken material from damaging the new threads.
3. Apply cutting fluid throughout the process to reduce heat and transport chips.
4. Keep the material and tap centered and level.
5. If you feel some restrictive force, turn anticlockwise for half a rotation and try again. Do not force the thread, or you risk breaking the tap or making incorrect threads.

6. Remove the tap: Turn the ratchet anticlockwise until the tap is entirely out. The tapping process is complete.

### **The die**



**The Die.**

Dies can thread a cylindrical materials outside surface, such as a rod, to make a bolt or screw. There are two general types of dies: the solid die and the adjustable die. A solid die cuts a nominal thread with a consistent depth. The accuracy is dependent on die precision and wear. The compression and release of the adjustable die is possible to achieve different classes of thread fit. Turning integrated screws adjust the die.

### **How to use a die?**

The process of threading with a die involves several steps that will be described below:

1. Prepare the rod: The material diameter should be slightly smaller than the dies major diameter. The die has a chamfered side used as the entry side for the rod. The chamfer helps to center the die on the rod and reduces the start turning force when threading.
2. Select die and wrench: Like the tapping process, use the chart to select the right die with an appropriately sized wrench.
3. Create the threads; Fasten down the material with a vice or clamp.
4. Place the die on the material with the chamfered side starting the threads. Center the die and align it, turn in the clockwise direction making two complete rotations.
5. Then turn anticlockwise for half a cycle. Repeat this process until the complete threading. Use cutting fluid as required.

6. Remove the die. Turn the wrench anticlockwise until the die is entirely out. The threading process is complete.

### **Selection criteria for tap and die sets**

There are several things to consider when choosing the right tap and die set to use. Here are the important ones:

1. Material: High-speed steel is more expensive than hardened carbon steel but is more robust and suitable for more material.
2. The number and range of pieces: Check that the set sizes are within your desired range of needed threads to cut.
3. Additional tools: Some sets come with additional tools and charts that can be useful.
4. Is the part corrosion resistant?
5. Check the application/material capabilities of the set listed in the manufacturers' product information.
6. Check that the carrying case is durable. The case stores the pieces.

### **QUESTIONS.**

1. a. Describe the following workshop hand tools and state one application of each
  - i. Chisel
  - ii. Snips
  - iii. Scriber
  - iv. Engineer's square
  - v. Taps (6 marks)
- b. Draw a labelled diagram of a vernier caliper (6 marks)
- c. Sketch a hand file and label four parts (4 marks)
2. a. Explain the difference between linear scale and non-linear scale
- b. i. State the functions of a divider
- ii. Draw a labelled diagram of a spring divider (8 marks)
- c. i. Draw a micrometer screw gauge reading 8.90mm
- ii. Outline the procedure of reading the 8.90mm on the scale in c(i) (7 marks)
- d. state three safety precautions observed in care of scribers (3 marks)
3. a. Draw a vernier scale to show a reading of 10.02cm (4 marks)
- b. List three:
  - i. cutting tools

- ii. marking out tools (6 marks)
- c. i. Draw a labelled diagram of a flat file (4 marks)
- ii. State FOUR precautions in handling and storage of files (4 marks)
- 4. a. State THREE reasons for marking out a piece of metal before cutting and filing (3 marks)
- b. Define the term tolerance as used in measurements (1 marks)
- c. i. Sketch and label a micrometer screw gauge. (6 marks)
- ii. State TWO functions of a micrometer screw gauge (2 marks)
- 5. State three:
  - i. Categories of fits
  - ii. Functions of a steel rule (6 marks)
- 6. Outline:
  - i. TWO factors considered when selecting a hacksaw blade (2 marks)
  - ii. THREE safety precautions observed when cutting a work piece using a hacksaw (3 marks)

## **TOPIC 4: JOINING OF METALS**

Joining can be defined as one of the manufacturing processes by which two or more solid components can be assembled together with or without the application of external elements such as filler, strap, heat, pressure, etc. There exist various joining techniques in order to assemble a larger variety of materials in innumerable ways. Some of these methods can join components permanently, while others can join temporarily. Accordingly, joining can be classified into two groups— temporary and permanent.

### **4.1: Mechanical joining of metals.**

#### ***4.1.1 Temporary removable joints***

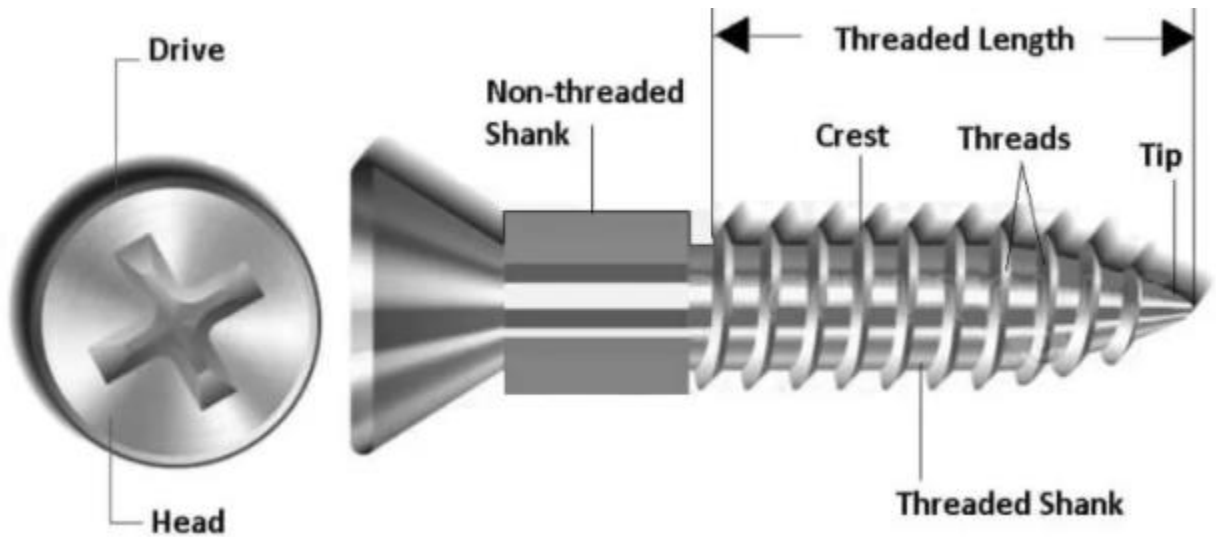
A temporary joint allows disassembly of assembled structures without rupturing the components. Easy disassembly makes inspection and maintenance very easy. However, strength of the temporary joints may not be as high as in a permanent joint.

Fasteners are the fast and foremost example for temporary joints. It includes, but not limited to, threaded elements like nut, bolt, screw, etc., clips, buttons, clamps, cables, nails, hooks, rings, bands, staples, etc. Apart from fasteners, joining by press fit, cotter joint, knuckle joint, etc. are also temporary joining elements. On the other hand, welding is one overwhelmingly accepted permanent joining process. Except this, rivet joint, coupling, soldering, brazing, etc. are considered as permanent joining processes. Most adhesive bonding also affix parts permanently.

#### ***4.1.2 Screws***

A screw is a broad category of mechanical fastener with a threaded shaft, designed to screw into a part. This includes wood screws and self-topping screws, which have a tapered shaft with sharp threads designed to cut a mating thread in the part to which they are fastened. It also includes machine screws,

which much more closely resemble bolts, but their entire shaft is normally threaded.



A screw will usually have a head on one end that allows it to be turned with a tool. Common tools for driving screws include screwdrivers and wrenches.

The head is usually larger than the body of the screw, which keeps the screw from being driven deeper than the length of the screw and to provide a bearing surface. There are exceptions. A carriage bolt has a domed head that is not designed to be driven.

Most screws and bolts are tightened by clockwise rotation, which is called a right-hand thread. Screws with a left-hand thread are used in exceptional cases, such as where screw will be subject to counterclockwise torque, which would tend to loosen a right-hand screw. For this reason, the left-side pedal of a bicycle has a left-hand thread.

### *Types of screws*



**1 Carriage Bolts**

Carriage bolts are forms of bolts used to fasten metal to metal or wood to metal. It is different from other bolts by its shallow mushroom head and the shank being rounded along its entire length.

The carriage bolt is designed with a domed head, which can prevent loosening from one side. The increased head size of the screw also prevents the bolt from being pulled through the wooden construction. Using a domed head nut prevents the carriage bolt from unlocking from the unprotected side.

## **#2 Decking Screws**



Deck screws are special screws used to hold decks (flat roofless structures) together primarily for outdoor applications. Decking screws are made of stainless steel or carbon steel and are specifically designed for joining wood or composite boards together.

They are made in such a way that they are capable of resisting coating like rust and corrosion due to which they can withstand damp environmental conditions. They are available in covered threads with sharp edges and narrow points.

### #3 Double Ended Screws



Double-ended screws are threaded fasteners used to form a joint that is usually under the object. These are used to two pieces of wood or two parts that are able to move together. They have two pointed ends that can be inserted into two surfaces, which will form a hidden joint.

They are headless screws with rotating threads at both ends which can be woodless screws with machine screws on both ends or a combination of wood screws. Double-ended screws are easily attached or detachable from the user, so they are easy to use.

### #4 Drywall Screws



Drywall screws are typically used to attach drywall panels with softwoods or metal studs. These are unique forms of self-tapping screws with a cylindrical shaft. These screws have deeper threads than

regular screws with a relatively higher pitch and length, which prevents them from loosening from the drywall.

They have a rough thread and flat tip that makes them easy to drill under the surface of drywall but requires a power screwdriver. Drywall screws provide a firmer grip but do not have the same corrosion-resistant properties as deck screws. They do not require pre-drilling the holes as they have their own drilling tip.

### **#5 Eye Bolt Screws**



An eye bolt is a bolt that has an eye-shaped loop at one end and threads around the shank of the screw at the other end. The eye bolt screws are used to attach a secure eye to a structure or system, so it becomes easy to tie ropes or cables.

These are very easy to carry in metal and provide stability plus strength so that an object can be easily pulled out or lifted with the help of rope. Eyebolt screws are normally used as a connection point for anchoring, pulling, pushing, or hoisting applications.

### **#6 Framing Screws**



Framing screws are types of screws used for sheet metal, wood, composite decking, and cement fiberboard applications. These special types of screw are designed to fit into varieties of materials from hardwood floors to brittle materials.

The function of framing screws is similar to circular saw blades because they prevent sawdust from reaching the edge of the screw hole. Framing screws are commonly seen in outdoor applications such as kitchen cabinet installation and deck building.

### **#7 Fillister Head Screws**



Fillister head screws are slotted head machine fasteners. These pan heads are similar to machine screws but are made of larger heads that can be useful for attaching metal or wood to metal. Often most of the time, these are also referred to as cheese head screws.

The heads of these screws are primarily chosen for counterbore holes. These sizable deep heads make them suitable for reciprocating and slot drives. But more generally, cheese head screws are a great selection for use in tool manufacturing and automotive applications.

## #8 Hex Cap Screws



Hex cap screws are six-sided bolts (hexagon) made with a perforated hex head and a washer face on the bearing surface. These types of screws are used to attach wood or metal to wood. These screws have [tight tolerances](#) on body [dimensions](#) and have a chamfer.

Hex screws have short steel threads making them ideal for interior home improvement projects. These screws also include a [flat washer](#) under the screw head and provide precise application. The major use of hex bolts is in docks, bridges, road structures, and buildings.

## #9 Hammer Drive Screws



These screws fall under the category of self-tapping screws. These screws are typically manufactured with rounded heads that have no slots. Hammer drive screws are used for attaching nameplates or wall signs, as well as are used to seal drain holes.

In addition, they are also highly useful for corrosion-resistant tubular structures. Screws have a similar function to nails as they are driven into the holes using a hammer or mallet for fast assembly purposes. Before installing them, it requires a small pre-drilled hole to complete the task successfully.

## **#10 Lag Screws**



Lag screws are used in heavy work and are often used in construction to fasten pieces of wood together. They are rigid screws that come in hex or square with thick threads and are able to hold up to heavy workpieces.

The lag bolt provides a long-lasting connection due to its long length. This is why they are used for materials that may be subjected to heavy force or can bear heavy loads. It is usually much heavier screws than traditional wood screws. These screws differ from ordinary wood or sheet metal screws.

## **#11 Machine Screws**



A machine screw fastening parts that have a socket in their head that allows it to be turned using a screwdriver. They are commonly employed to hold parts of machines in industries such as electronics, engineering, and manufacturing equipment.

These screws are specifically used to fasten a tapped hole to the surface using a nut. The screws are stretched when tightened, and tensile loads secure the parts together. Normally, Their pointed ends are used to connect metal parts together. Nowadays, they are seen in almost every material including nylon, brass, stainless steel, and carbon steel.

### **#12 Masonry Screws**



Masonry screws are heavy-duty screws used to hold strong materials such as concrete, CMU, mortar joints, and brick in place. They are made of stainless or carbon steel and come with or without a rust coating.

Fitting a masonry screw requires a pre-drilled small hole using a carbide bit or hammer drill before being inserted. Masonry screws are available in two types: a flat head for countersinking, or a hex washer head to sit on the top of the surface of the material.

### **#13 Oval Head Screws**



These screws are known in the shape of undercut or trim heads with shorter screw lengths that usually give a longer thread grip. Oval-head screws are somewhat countersunk, with the screw head about halfway above the surface.

The oval countersunk screw heads have a rounded finish top and are mostly used to cover switches. They are also considered a good option to make the finished product more attractive. These types of screws are generally available in two types, rounded head screws, and Phillips oval head screws.

### **#14 Pan Head Screws**

Pan head screws are a common head type of non-countersunk screw head used in woods. These are also self-tapping, self-drilling, and machine screws. They have wide heads, a flat bearing surface, a flat head with rounded sides that sit on top of the material it fastens to.

With its larger diameter and higher edges, the drive slot is deeper, allowing for increased torque while reducing the risk of screw damage. Pan-head screws with single cuts in slotted heads are a type of pan head screws that works with any screwdriver. The main purpose of using these screws is to secure metal components like machinery and [automotive engine parts](#).

### **#15 Particle Board Screws**

Particle board screws are full-length threaded screws. The advantage of these screws is that the longer thread yields greater engagement and higher pulling force. This type of screw is designed for composite wood such as laminated particle board or craftwood. And is used by cabinet makers in domestic and commercial joinery.

Particle board screws are similar to drywall screws but are available in shorter lengths than standard drywall screws. Due to their lightweight, they can be easily carried and handled. These screws are used by cabinet makers in domestic and commercial joinery.

### **#16 Square Head Bolts**

Square head bolts are like hex cap screws but have a four edge square head instead of a six edge hexagonal head. They are also known as both bolts and screws and are designed to work with a wrench. These screws are threaded partially along a shoulder under the head.

The function and purpose of a square head screw determine the size of the head of the bolt. This type of screw is used to tighten the nut as well as two parts. Square head screws were the industry standard before hex bolts gained importance.

### **#17 Self-drilling Screw**

Self-drilling screws come with a highly sharp pointed end that almost work as a [drill bit](#) and cutting threads useful tap holes during installation. Because they have a tip like a drill bit, they don't require pilot holes. Self-drilling screws are typically used screws for quick drilling in both metal and wood.

These are usually be determined by their point and flute tip. They can drill and tap their own holes in harder materials saves you using the tool. These screws are easy to find because of their point, which curves at the end and is look like a twist drill.

### **#18 Set Screws**

A set screw is a screw used to secure an object within or against another object such as fixing a pulley or gear on a shaft by applying pressure and/or friction. A set screw is typically used without a nut that is screwed into a threaded hole drilled in two objects to secure it.

Once the screw fits into the first object, the projected end of the set screw presses firmly against the second object, working similarly to a clamp. These are often headless and are threaded along their entire length so that it sits completely inside the hole.

### **#19 Shoulder Screws**

This type of screw fits into one part and provides a freely rotating pin joint connection in the other. It consists of a large diameter shank just below the head which is a smaller diameter for the threaded length.

This design allows a shoulder screw to be fitted firmly to one part without locking the other part, giving it axial clearance. These screws provide versatility by acting as a shaft for rotating items such as shoulder bearings.

### **#20 Sheet Metal Screws**

Sheet metal screws can bind or join two pieces of sheet metal to other types of metal, such as tubing. Sheet metal screws can secure and tighten metal objects to each other or fasten objects. These screw sizes are available which include flat, hex, and round.

Sheet metal screws have pointed ends and include a fine thread along the shank. These screws work by drilling into the sheet metal with the fully threaded shank. The advantage of using these screws is that they can provide excellent penetration, corrosion-resistant, and superior holding.

### **#21 Socket Head Screws**

A socket cap screw is a type of machine screw that has a cylindrical barrel-shaped head with a hexagonal socket. Due to their cylindrical heads and internal wrenching features, they allow for use in locations where externally dampening fasteners are not desirable.

These screws are perfect when needing a fastener to sit under the surface of the material. Wherever a joint is required, they can deliver extremely strong and reliable plus they are also resistant to corrosion. Apart from these, they give an attractive and quality finish.

### **#22 Thread Cutting Screws**

These types of screws have sharp edges because the depth of the hole is slightly longer than that of the screw. This arrangement will keep the metals from getting locked inside the device. Thread cutting screws are often used with wood and metal.

The purpose of using these is to reduce the build-up of internal tool stresses, thus making them ideal for extremely hard materials. Unlike a thread-forming screw, it does not have a cutting edge, which is difficult in materials with low compressive strength.

### **#23 Washer Faced Screws**

These types of screws act as springs to decrease the distance between the nut and the head of the screw. The washer-faced type screws are available in many types and sizes.

Basically, some types have teeth that penetrate the surface and lock the screw head into the workpiece. In this type, the washer face is located just below the head, providing a smooth bearing surface for easy tightening.

#### **#24 Wood Screws**

As the name suggests, this type of screw is used to attach a wooden workpiece. A wood screw is commonly made of brass, steel, and bronze materials. Wood screws have different threads and are available in a variety of heads.

As we move towards the top of the screw, it thins a bit, the diameter of the screw being thicker than the tip. These are available in both the options which are partially or fully covered threads at the shank. The head size of this screw depends on different applications.

#### **#25 Weld Screws**

These are needed to be welded to a metal surface with a shaft to hold the item in place with a nut and washer. The screw is first welded to the plate by melting a specially created point on the screw and then on the plate by means of a powerful electrical impulse.

The welded screw protrudes from the head to allow welding without any holes. The welding stud is then attached to a piece of metal that is positioned on the metal base. They are used in the automotive, industrial, marine, construction, and aerospace industries.

#### **#26 Tamper-proof Screws**

Tamper-proof screws are made difficult or impossible to remove when installed. These are suitable for use in buildings or areas that are accessible by the public as a means of controlling or preventing destruction.

These are the types of safety screws that can be determined by their unconventional drive resulting in more difficulty to tamper or take apart. These screws are primarily used in prisons to secure materials such as car license plates, gutters, and grill bars.

#### ***4.1.3 Bolt and nuts***

A nut is a small metallic piece of metal with a spiral cut groove that runs around a hole in its center while a bolt is a metallic piece with a round stem as its body and threaded into one end. Bolts have different length sizes while nuts have a standard size.

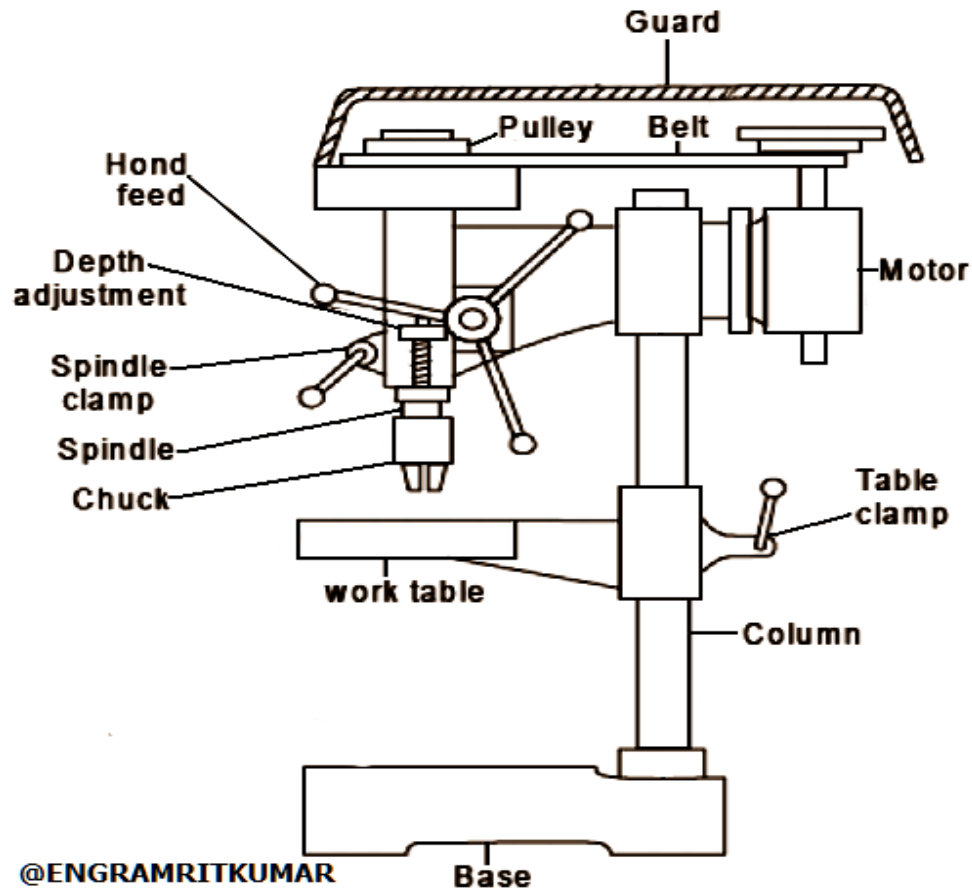
## **TOPIC 5: WORKSHOP MACHINES AND APPLICATIONS.**

### **1. Drilling Machine:**

Drilling machine is one of the most important machine tools in a workshop. It was designed to produce a cylindrical hole of required diameter and depth on metal workpieces. Though holes can be made by different machine tools in a shop, drilling machine is designed specifically to perform the operation of drilling and similar operations. Drilling can be done easily at a low cost in a shorter period in a drilling machine. Drilling can be called as the operation of producing a cylindrical hole of required diameter and depth by removing metal by the rotating edges of a drill. The cutting tool known as drill is fitted into the spindle of the drilling machine. A mark of indentation is made at the required location with a center punch. The rotating drill is pressed at the location and is fed into the work. The hole can be made up to a required depth.

### **Construction of a drilling machine:**

The basic parts of a drilling machine are a base, column, drill head and spindle. The base made of cast iron may rest on a bench, pedestal or floor depending upon the design. Larger and heavy-duty machines are grounded on the floor. The column is mounted vertically upon the base. It is accurately machined, and the table can be moved up and down on it. The drill spindle, an electric motor and the mechanism meant for driving the spindle at different speeds are mounted on the top of the column. Power is transmitted from the electric motor to the spindle through a flat belt or a 'V' belt.



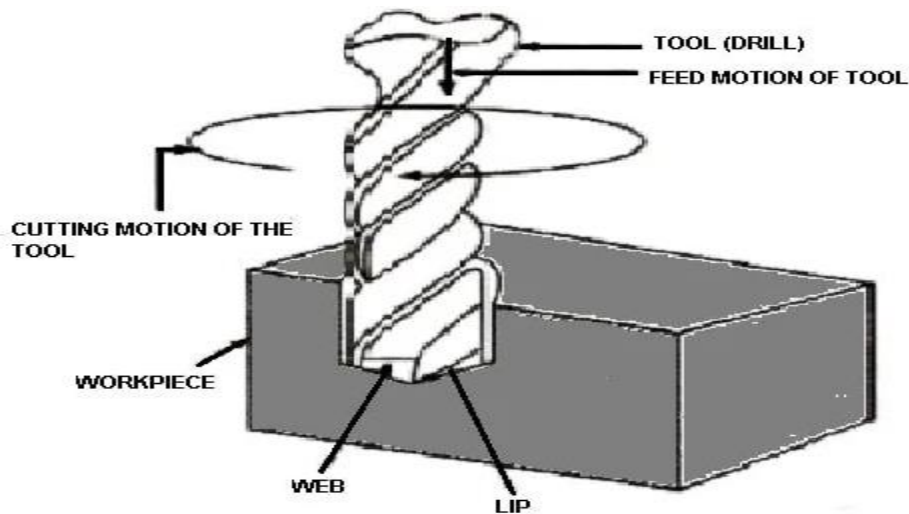
**Drilling Machine.**

## Drilling Operations.

### *1. Drilling*

Drilling is the operation of producing a cylindrical hole by removing metal from the rotating edge of a cutting tool called the drill.

Drilling is one of the simplest methods of producing a hole. Before drilling the centre of the hole is located on the workpiece by drawing two lines at right angles to each other and then a centre punch is used to produce an indentation at the centre.

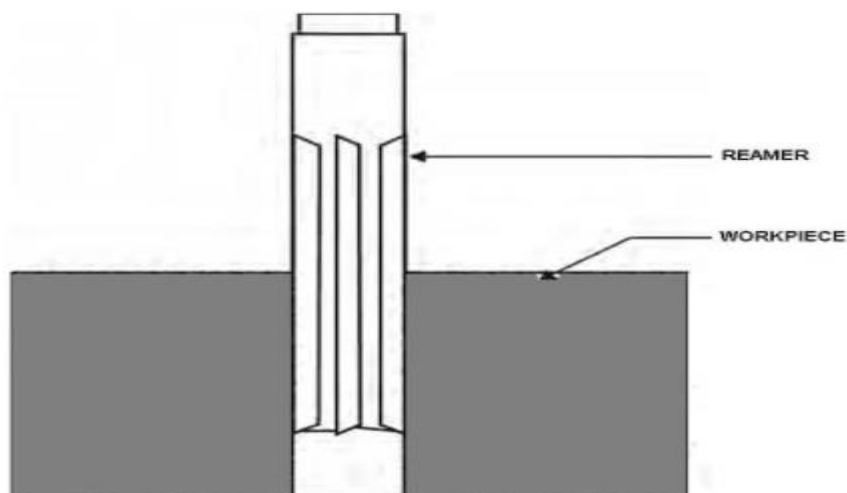


The drill point is pressed at this centre point to produce the required hole. Drilling does not produce an accurate hole in a workpiece and the hole location is not perfect.

The internal surface of the hole so generated by drilling becomes rough and the hole is always slightly oversize than the drill used due to the vibration of the spindle and the drill. A 12mm drill may produce a hole as much as 0-125mm oversize and a 22mm drill may produce one as much as 0-5mm oversize.

## 2. Reaming

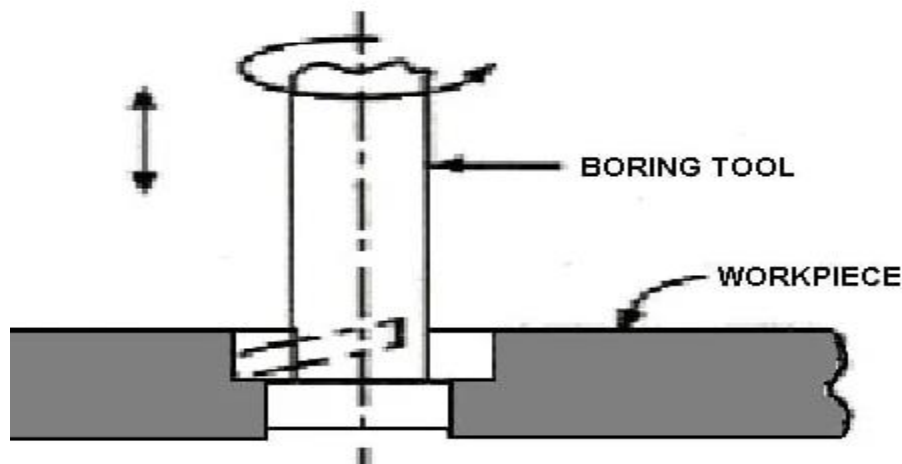
Reaming is an accurate way of sizing and finishing a hole which has been previously drilled. In order to finish a hole and to bring it to the accurate size, the hole is drilled slightly undersize.



The speed of the spindle is made half that of drilling and automatic feed may be employed. The tool used for reaming is known as reamer which has multiple cutting edges.

Reamer cannot originate a hole. It simply follows the path which has been previously drilled and removes a very small amount of metal. For this reason, a reamer cannot correct a hole location. The material removed by this process is around 0-375mm and for accurate work, this should not exceed 0-125mm.

### ***3. Boring***



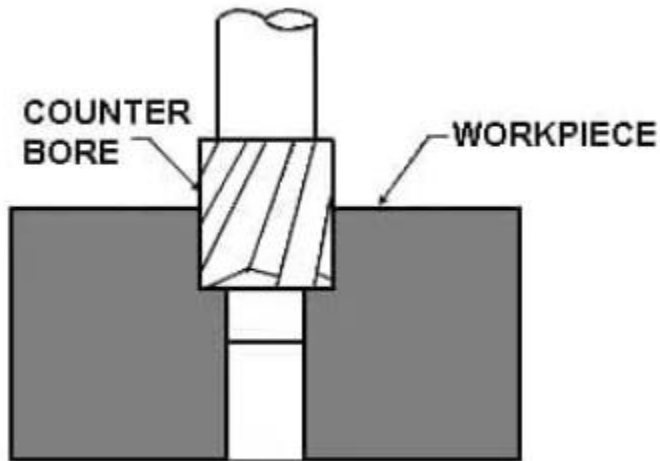
Boring is performed in a drilling machine for reasons stated below:

- To enlarge a hole by means of an adjustable cutting tool with only one cutting edge. This is necessary where the suitable sized drill is not available or where the hole diameter is so large that it cannot be ordinarily drilled.
- Used to finish a hole accurately and to bring it to the required size.
- To machine the internal surface of a hole already produced in casting.
- Used to correct out of roundness of the hole.
- To correct the location of the hole as the boring tool follows an independent path with respect to the hole.

The cutter is held in a boring bar which has a tapered shank to fit into the spindle socket. For perfect finishing a hole, the job is drilled slightly undersize. In precision machines, the accuracy is as high as  $+0.00125\text{mm}$ . It is a slow process than reaming and requires several passes of the toll.

#### 4. Counterboring

Counterboring is the operation of enlarging the end of a hole cylindrically. The enlarged hole forms a square shoulder with the original hole. This is necessary in some cases to accommodate the heads of bolts, studs and pins.



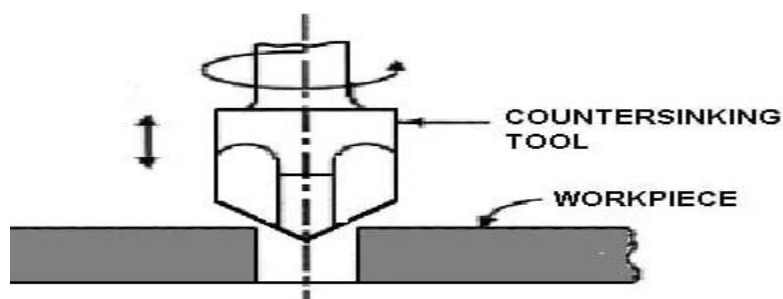
A tool used for counterboring is called a counterbore. The counterbores are made with a straight or tapered shank to fit in the drill spindle. The cutting edges may have straight or spiral teeth.

The tool is guided by a pilot which extends beyond the end of the cutting edges. The pilot fits into the small-diameter hole running clearance and maintains the alignment of the tool.

These pilots may be interchanged for enlarging different sizes of holes. Counterboring can give an accuracy of about  $+0.005\text{mm}$ . The cutting speed for counterboring is 25% less than that of drilling operations.

#### 5. Countersinking

Countersinking is the operation of making a cone-shaped enlargement of the end of a hole to provide a recess for a flat head screw or countersunk rivet fitted into the hole.



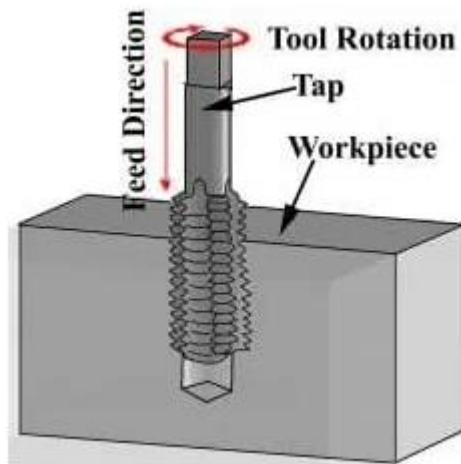
The tool used for countersinking is called a countersink. Standard countersinks have 60, 82 or 90 inclined angle and the cutting edges of the tool are formed at the conical surface. The cutting speed in countersinking is 25% less than that of drilling.

### **6. Spot facing**

Spot facing is the operation of smoothing and squaring the surface around a hole for the seat for a nut or the head of a screw. A counterbore or a special spot facing tool may be employed for this purpose.

### **7. Tapping**

It is the operation of cutting internal threads by means of a cutting tool called a tap. Tapping in a drilling machine may be performed by hand or by machine.



A tap may be considered as a bolt with accurate threads cut on it. The threads act as cutting edges which are hardened and ground. When the tap is screwed into the hole it removes metal and cuts internal threads which will fit into external threads of the same size.

### **8. Lapping**

Lapping is the operation of sizing and finishing a small diameter hole already hardened by removing a very small amount of material by using a lap. There are many kinds of lapping tools.

The copper head laps are commonly used. The lap fits in the hole and is moved up and down while it revolves.

## **9. Grinding**

Grinding operation may be performed in a drilling machine to finish a hardened hole. The grinding wheel is made to revolve with the spindle and is fed up and down.

A suitable grinding wheel may be selected for surface grinding operation. Grinding can also be done correctly out of roundness of the hole. The accuracy in grinding operation is quite high about  $+0.0025\text{mm}$ .

## **10. Trepanning**

Trepanning is the operation of producing a hole by removing metal along the circumference of a hollow cutting tool.

This operation is performed for producing large holes. Fewer chips are removed and much of the material is saved while the hole is produced.

The tool may be operated at higher speeds as the vibration in diameter of the tool is limited by the narrow cutting edge. The tool resembles a hollow tube having cutting edges at one end and a solid shank at the other to fit into the drill spindle. This is one of the efficient methods of producing a hole.

### **Safety Precautions When Using A Drill.**

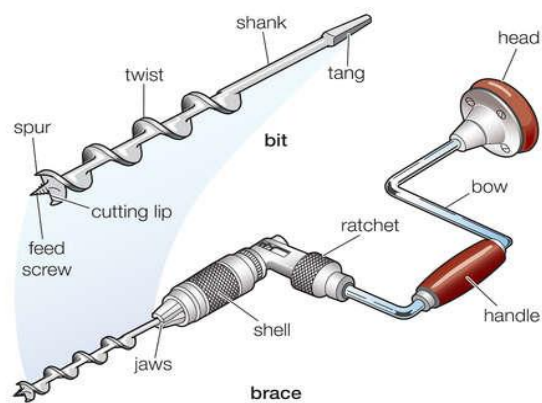
It is necessary that no damage is done to the operator, the machine tool and the cutting tool. To ensure this, the following points are to be remembered.

1. The work should not be held by hand in any case.
2. Proper work holding device should be used to hold the work. If the work is not held properly, the work tends to rotate along with the drill causing damage to the operator, the machine tool and the cutting tool.
3. The shank of the drill should conform with the spindle hole.
4. Cutting speed and feed should be selected according to the prescribed range.
5. Care should be taken to ensure whether the belt and gears are connected properly.
6. Proper safety plates should be installed around rotating parts like belt drive and gears.
7. The operator should wear safety goggles while operating the drilling machine.
8. The machine should be disconnected from electric terminals when repairs are in general, we should ensure the proper functioning of the machine tool.

## 2. Hand Drill:

A hand drill is a manual tool that converts and amplifies circular motion of the crank into circular motion of a drill chuck. Though it has been replaced in most applications by power drills, the hand drill is used by many woodworkers.

The hand drill consists of a cranking handle that turns pinion gears on the main shaft. A chuck at the end of the shaft holds a drill bit. The opposite end of the shaft has a second handle that is held stationary while the chuck turns. The drill bit is selected to cut a hole of a specific width, such as 3/8 inch; the size typically is inscribed on the bit's shaft.



**Hand Drill.**

### ***Operation of a hand drill:***

To safely use a hand drill, loosen the chuck and insert the appropriate drill bit, then tighten the chuck. Place the bit's tip where you want to cut a hole, making sure the bit is at the same angle as the desired hole. Turn the cranking handle to rotate the bit and drill the hole. With smaller drill bits, be careful not to apply excess pressure on the handle or the bit may bend or break.

### ***Maintenance:***

Hand drills require little maintenance, but can be damaged by improper use, such as using the wrong drill bit or placing excess pressure on the tool. For optimum efficiency, periodically place a drop of light oil on the crank pinions and in the chuck gear.

## 3. Power Drill:

A power drill is an electrical motor that rotates a replaceable drill bit to make a hole in wood, plastic, or metal. Alternately, a screwdriver tip can be installed to turn screws. The parts of a power drill include the handle, an on/off trigger with safety latch, a reversing switch for changing the rotation direction of the

drill bit, a torque adjustment, and the chuck that holds the drill bit in place. Corded drills are powered by a 110-volt electrical cord inserted into an electrical receptacle; cordless drills are powered by a battery in the drill's handle.



**Power Drill.**

**Safety use of a power drill:**

To safely use a power drill, first make sure the drill switch is in the off position and/or unplug the electrical cord if so equipped. Loosen the chuck and insert the appropriate bit or tip shaft, then tighten the chuck. Some power drills require a special tool to firmly tighten the chuck. As needed, set the torque adjuster to control slippage of the drill bit, useful when turning screws without damaging the screw head. Plug in or insert the battery into the power drill. Place the point of the drill bit or screwdriver tip as needed. Press the safety latch and on/off trigger. Push the drill bit or screwdriver forward as the chuck rotates.

**4. Center Lathe.**

The center lathe or metal turning lathe is a machine used to turn metal or plastic bar into cylindrical shapes. In addition, there are many other operations that can be done on this type of lathe.

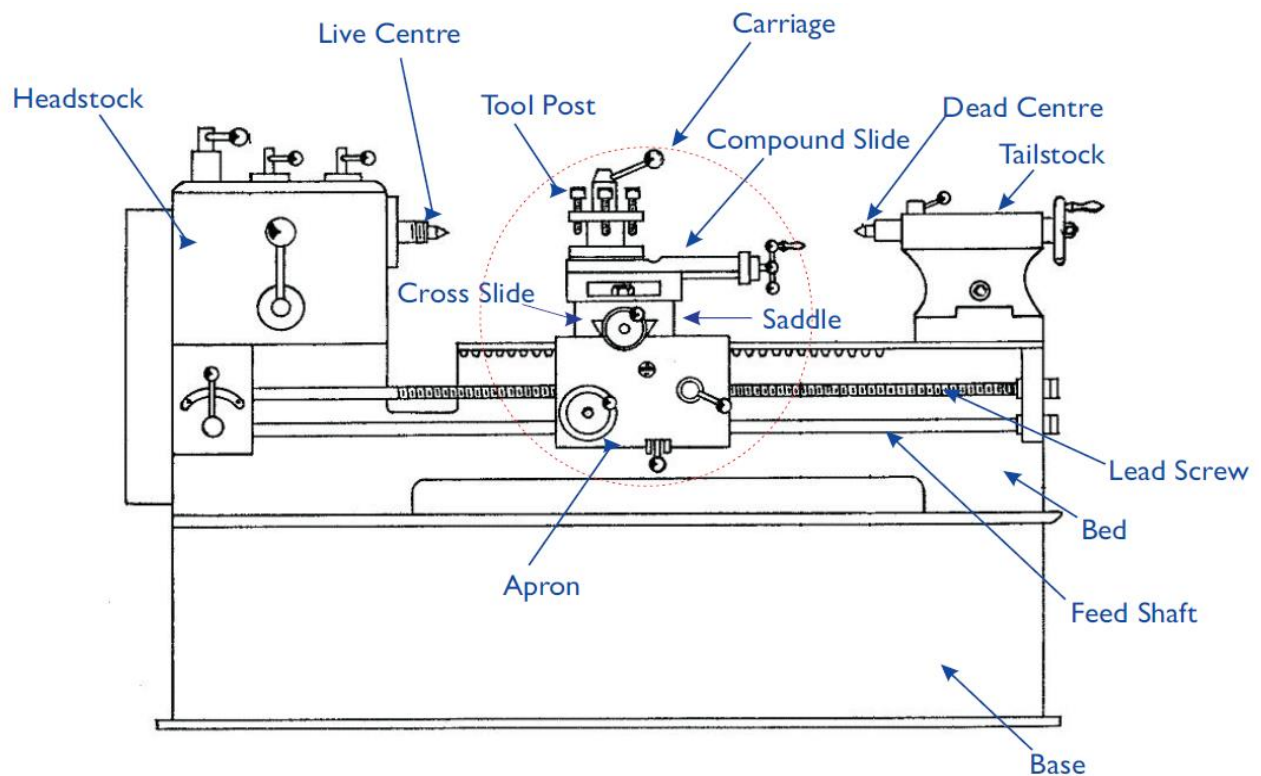
The work, which usually rotates towards the operator, can be gripped securely in a chuck, bolted to a face plate or set up between two centers. The cutting tool mounted on a tool post on the top of the carriage can be moved along the bed or at right angles to it. The length ways movement (or traverse) of the cutting tool produces a circular surface on the workpiece and the cross transverse produces a flat surface.

In addition to these operations the center lathe is used in the school workshop for producing tapered work (with the compound slide), for drilling and boring holes, parting off, knurling and screw cutting.

The size of the lathe is specified by (a) the maximum distance between centers and (b) the height of the spindle center above the lathe bed.

The main parts of the center lathe are:

1. The Bed
2. The Headstock
3. The Tailstock
4. The Carriage



### Center Lathe Machine.

#### The Bed:

The bed of the lathe is made from cast iron for strength and rigidity. Its surfaces are machined true and accurate to ensure smooth movement of the tailstock and carriage and perfect alignment of these components with each other with the headstock.

### **The Headstock:**

The headstock is securely fixed onto the left-hand end of the bed and carries the drive gearing and main spindle. This spindle is hollow to take tapered centers and allow metal and plastic of suitable diameter to pass through. It is also screwed at the right-hand end to enable chucks and face plates to be easily attached and removed. This spindle, known as the 'live' center because it rotates with the work, is driven by a series of gear wheels whose power is transmitted by means of v-belts from an electric motor.

### **The Tailstock:**

The tailstock has a hollow spindle designed to take tailstock (or dead) centers and drill chucks. In use the tailstock center supports the 'free' end of the work being turned whilst the drill chuck is used when drilling or reaming work that is held in a chuck or face plate.

The tailstock can be in the desired position by sliding it smoothly along the bed and clamping securely with the tailstock bed clamp. Fine adjustment, to bring the 'dead' center up to the work, is made with the hand wheel. The outer surface of the spindle is graduated in millimeters to allow holes of an exact depth to be drilled. The spindle is clamped in position using the spindle clamp.

### **The Carriage:**

The carriage unit consists of the saddle, cross slide, compound slide (or rest), tool post and apron.

The **Saddle**, or carriage base, spans the bed of the lathe and moves smoothly on the bed guides, when the apron hand wheel is turned or when automatic feed is engaged.

The **Cross Slide**, mounted on a dovetail shaped section on top of the saddle, can be moved at right angles to the bed length by using the cross-feed handle.

The **Compound Slide**, which carries the tool post and cutting tool, is fed by hand only. It is attached to the top of the cross slide by a swivel pin and can be pivoted and locked at any desired angle when turning short tapers, boring or screw cutting.

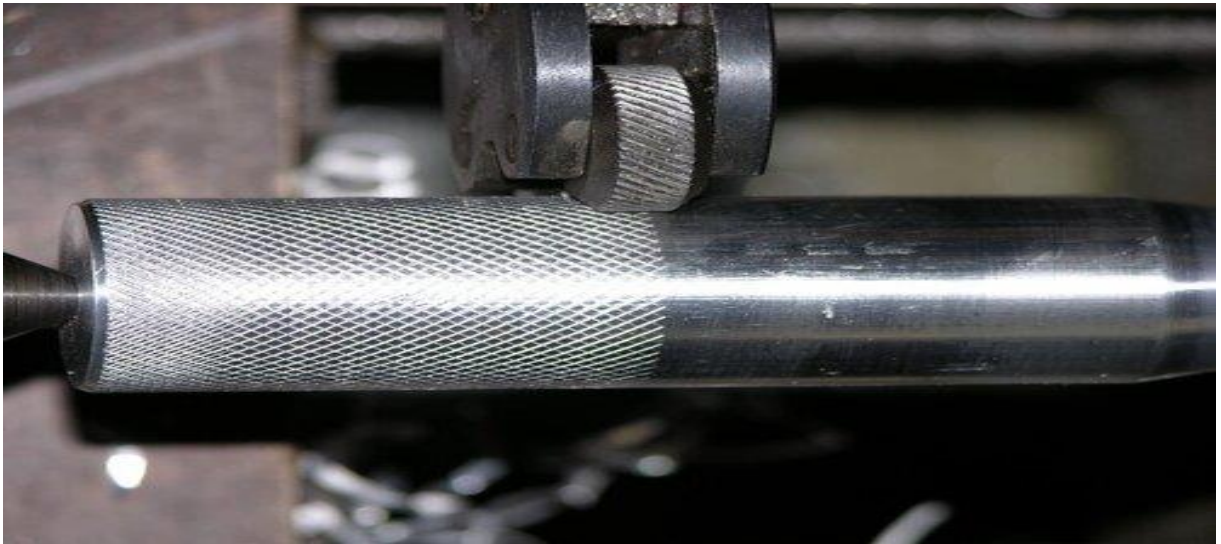
The **Apron** hangs down from the front edge of the saddle. The lead screw, or feed shaft, passes through the apron and when engaged by the appropriate gearing and controls cause the whole carriage to move smoothly along the bed. The apron also contains the feed mechanism and control for the automatic movement of the cross slide.

### Other uses of lathe:

**Resources:** [10 Turning Operations You Need To Know — Swiss-Turning Specialists | Turntech Precision](#)

- Knurling:

Knurling is a process of impressing a diamond-shaped or straight-line pattern into the surface of a work piece. Knurling is essentially a roughening of the surface and is done to provide a better gripping surface.

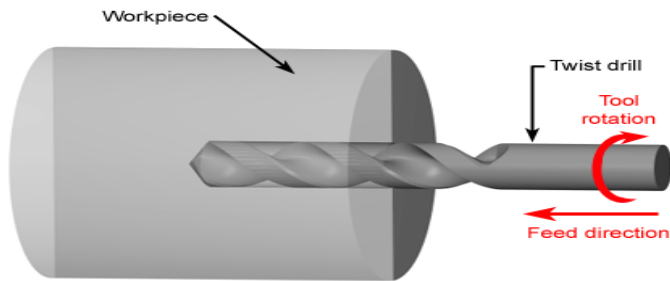


- Turning:

During the turning process, a cutting tool removes material from the outer diameter of a rotating workpiece. The main objective of turning is to reduce the workpiece diameter to the desired dimension. Four types of turning operations are the **step turning**, **contour turning**, **taper turning** and **chamfer turning**.

- Drilling:

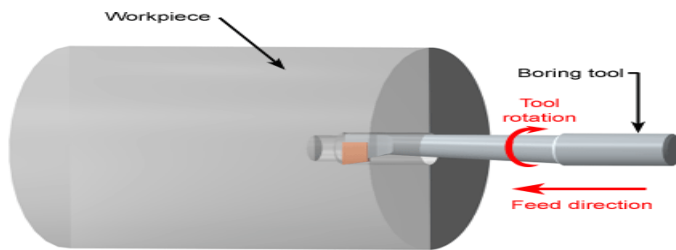
Drilling operation removes the material from the inside of a workpiece. The result of drilling is a hole with a diameter equal to the size of the utilized drill bit.



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- Boring:

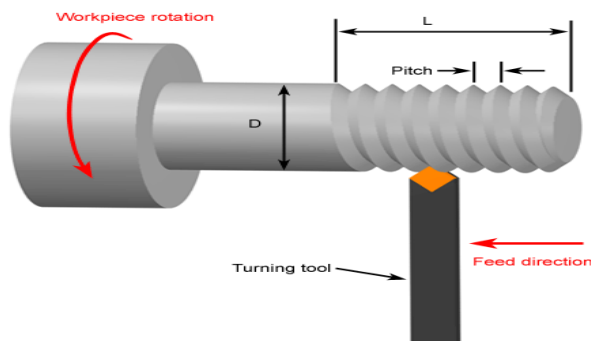
In boring operation, a tool enters the workpiece axially and removes material along the internal surface to either create different shapes or to enlarge an existing hole.



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- Threading:

Threading is a turning operation in which a tool moves along the side of the workpiece, cutting threads in the outer surface. A thread is a uniform helical groove of specified length and pitch.



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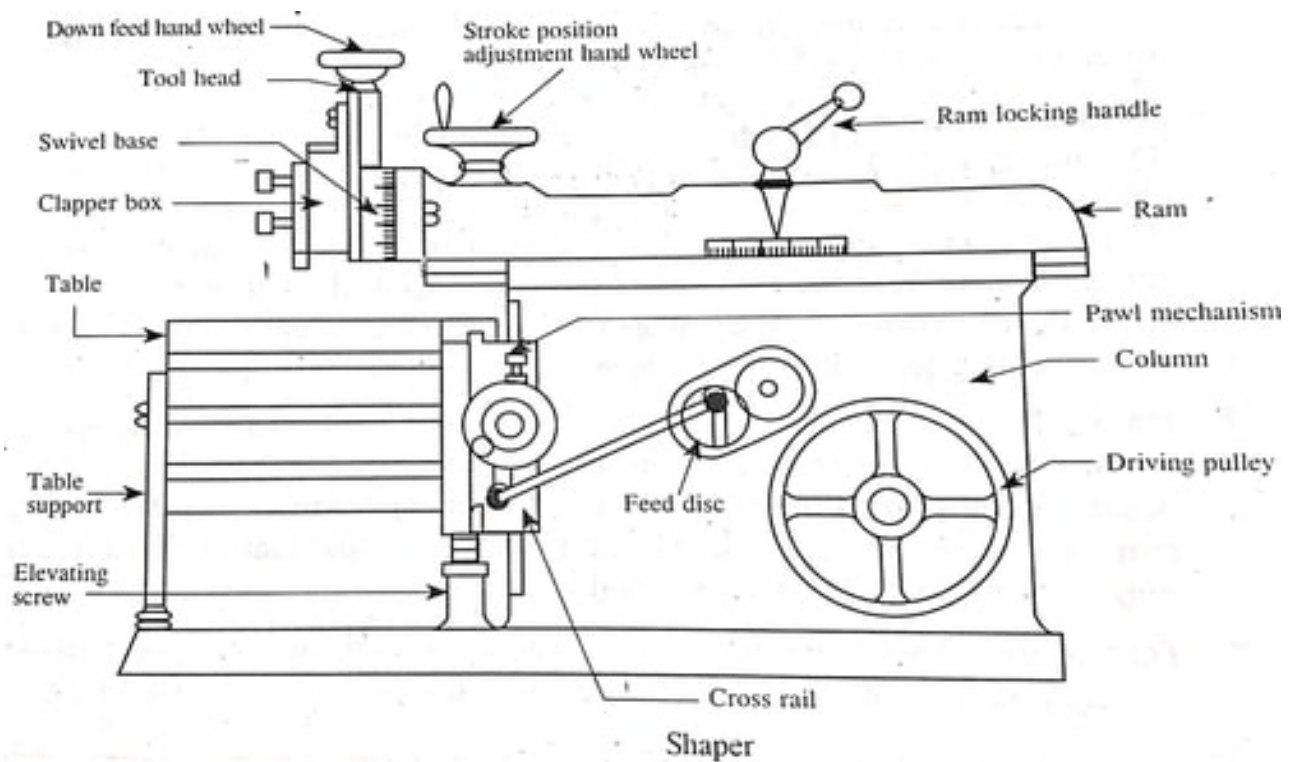
- Facing:

Facing is the process of removing metal from the end of a workpiece to produce a flat surface.



### 5. Shaping Machine.

A shaping machine is used to machine surfaces. It can cut curves, angles and many other shapes. It is a popular machine in a workshop because its movement is very simple although it can produce a variety of work. Shaping machines come in a range of sizes but the most common size is seen below.



The tool feed handle can be turned to slowly feed the cutting tool into the material as the 'ram' moves forwards and backwards. The strong machine vice holds the material securely. A small vice would not be suitable as the work could quite easily be pulled out of position and be damaged. The vice rests on a steel table which can be adjusted so that it can be moved up and down and then locked in position. Pulling back on the clutch handle starts the 'ram' moving forwards and backwards.

### **Parts of a shaping machine.**

#### *Base:*

Just as other machine tools, base is designed to take the entire load of the shaping machine. It is bolted on the floor of workshops. Base are made of cast iron in order to resist vibration and to take the compressive load.

#### *Column:*

The column is a cast iron mounted on the base. It is provided with accurately machined guideways on the top on which the ram reciprocates. Some guideways are also provided on the front vertical face for the cross-rail movement. All ram driving mechanisms are enclosed in the column.

#### *Cross-rail:*

The shaping machine's part is mounted on the ground vertical to guideways of the column. It features two parallel guideways on its top, perpendicular to the ram axis, this is called a saddle. It helps to move the table in a crosswise direction by the help of a feed screw.

A cross-rail allows the table to be raised and lowered at a required size the workpiece will accommodate. This is done by the rotating the elevating screw that causes the crossrail to slide up and down on the vertical face of the column.

#### *Saddle:*

A saddle is mounted on the cross rail to hold the table firmly on its top. The crosswise movement of the saddle causes the table to also move in a crosswise direction if the cross-feed screw is rotated.

*Table:*

A table is mounted on the saddle, it moves crosswise by rotating the cross-feed rod and vertically by rotating the elevating screw. The table is made of cast iron, in the shape of a box with an accurate top and side surfaces. These surfaces features t-slots for holding the workpiece.

In a universal shaping machine, the table is designed to swivel on a horizontal axis and its upper part is tilted up or down.

*Ram:*

A ram is a reciprocating member that holds a shaping tool. It is in form of a semi-cylindrical and ribbed inside which make it more rigid. It holds the screwed shaft for altering the position of the ram with respect to the work.

*Tool head:*

The tool head is designed to firmly hold a cutting tool and offers both vertical and angular movement to the tool. This movement is done by a down feed screw handle. The tool head also allows the tool to have an automatic relief during the return stroke of the ram. The head tool consists of apron, clapper box and a clapper block; the apron contains the clapper box and tool post, clamped on the vertical slide by the screw. The apron is swiveled upon the apron swivel pin in a direction of right or left. The clapper box houses the clapper block using a hinge pin. A tool post is mounted on the clapper block.

## **6. Grinding Machine.**

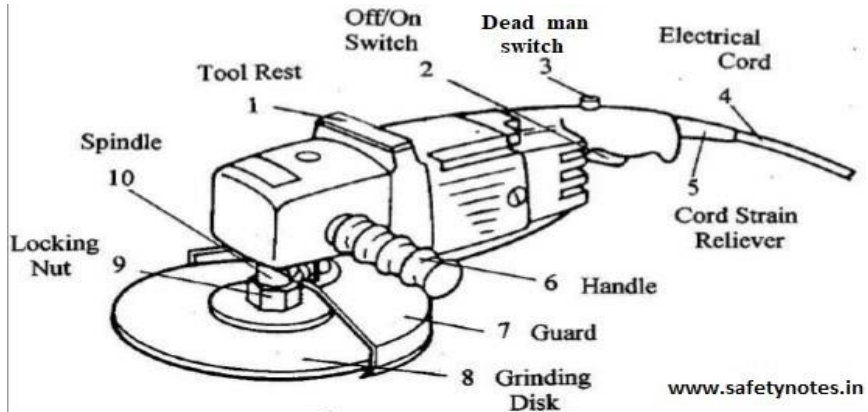
A grinding machine is a machine tool equipped with an abrasive wheel used for producing fine finishes or making light cuts on metals and other materials. There are various types of grinding machines. Their wheels, which differ in size and grain, are made up of a variety of stones, diamonds, and other inorganic materials. These machines are useful for roughing and finishing operations on tools and other equipment.

***Construction:***

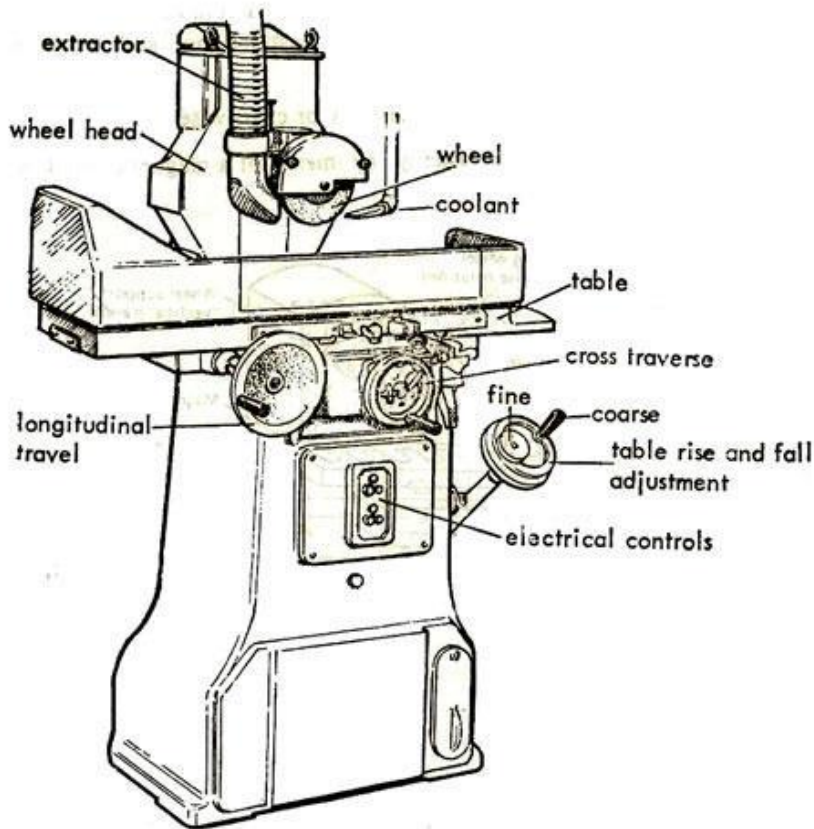
The grinding machine consists of a power-driven grinding wheel and a bed with a fixture to guide and hold the workpiece. The wheel is made to spin at the desired speed, based on the wheel's diameter and manufacturer's rating, usually by a formula. The grinding head can be controlled to travel across a fixed workpiece, or the workpiece can be moved whilst the grinding head stays in a fixed position. Very fine

control of the grinding head or table position is feasible using a Vernier calibrated hand wheel or using the features of numerical control (NC) or computer numerical control (CNC).

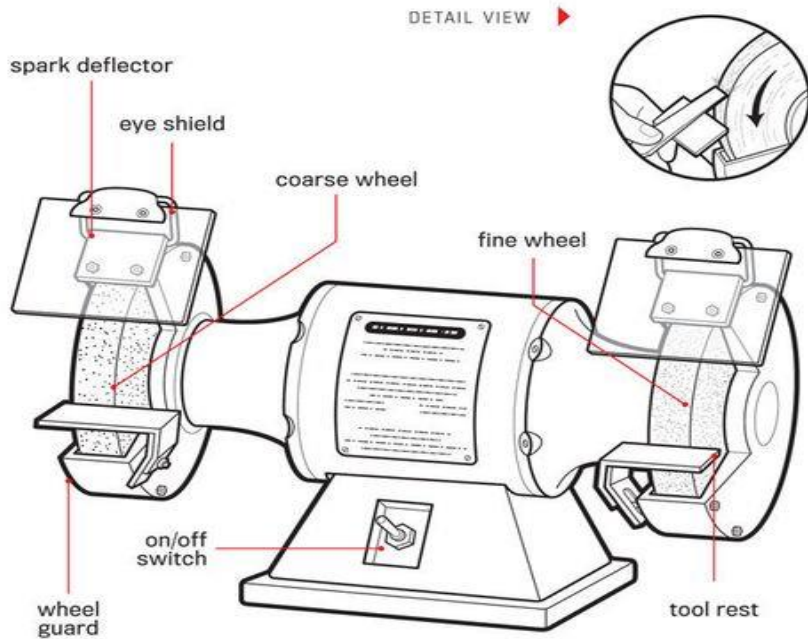
Grinding machines remove material from the workpiece by abrasion, which can generate substantial amounts of heat. They therefore incorporate a coolant to cool the workpiece so that it does not overheat and exceed its tolerance range. The coolant also benefits the machinist, as the heat generated may cause burns in some cases.



Hand grinder



Pedestal grinder.



Bench grinder.

### Types of grinding machines.

**Resources:** [14 Types of Grinding Machines \[Working, Diagram & PDF\] \(theengineerspost.com\)](http://theengineerspost.com)

1. Bench grinding machine
2. Hand grinding machine
3. Pedestal grinding machine
4. Portable grinding machine
5. Flexible grinding machine
6. Precision grinding machine
  - a. Cylindrical grinder
  - b. Plunge cut grinder
  - c. Form grinder
  - d. Internal grinder
  - e. Centreless grinder
  - f. Surface grinder
  - g. Universal grinder
  - h. Tools and cutting grinder