MECHANICAL ENGINEERING SCIENCE (UE23ME131A)

Srinivasa Prasad K S

Department of Mechanical Engineering

MECHANICAL ENGINEERING SCIENCE

Unit4

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MECHANICAL ENGINEERING SCIENCE

Chapter 1 – Machining Processes

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INTRODUCTION TO MACHINING PROCESSES

- **Machining is the process of removing the excess material from the work piece in the form of chips, by forcing the cutting tool with one or more cutting edges.**

- Casting processes and the metal working processes are the primary manufacturing processes where the metal is first shaped into an intermediate shape which is normally brought to its final form with metal cutting process.

- Assembling of parts into workable equipment often requires the mating surfaces to be complementary to each other in terms of form, dimensions and surface finish. The only way this can be achieved is through the use of material removal processes.

MACHINE TOOL

- Machine Tool is a power driven machine to perform machining

- Machine Tool performs three major functions:
  -It rigidly supports the work piece and cutting tool
  -Provides relative motion between work piece and cutting tool
  -Provides range of speeds and feeds

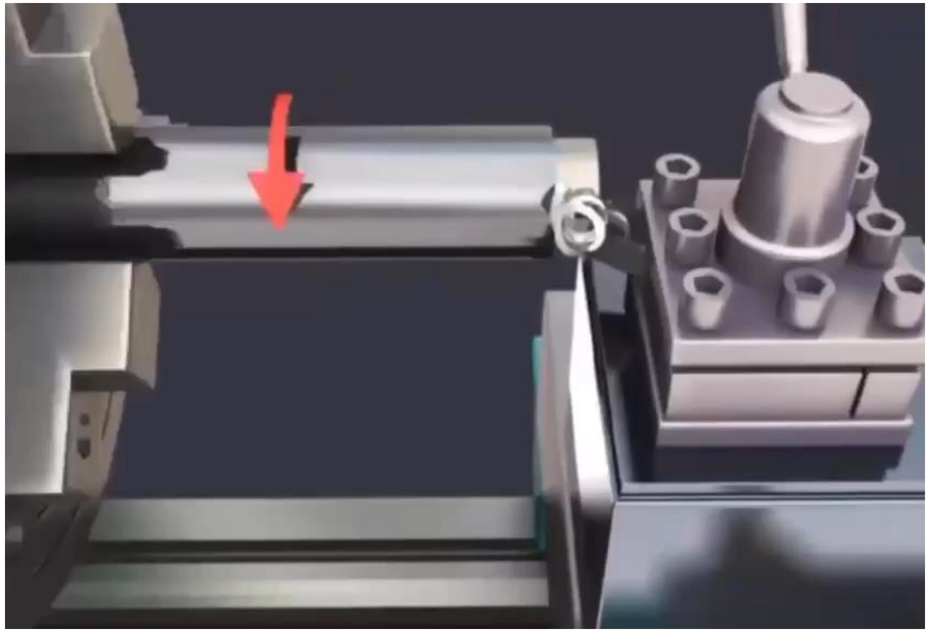
INTRODUCTION TO LATHE

- Lathe is the oldest machine tool invented, starting with the Egyptian tree lathes.

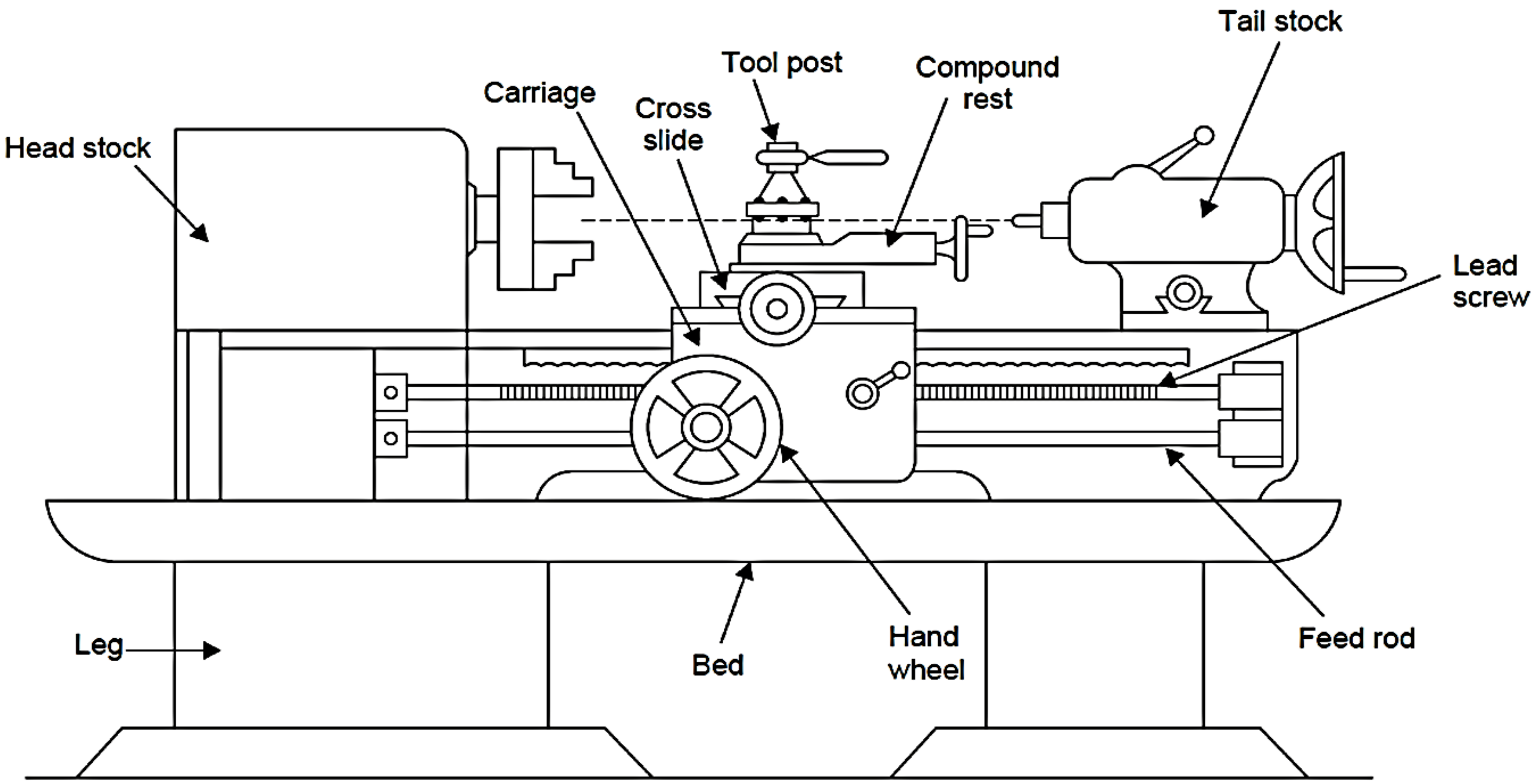
- The principal form of surface produced in a lathe is the **cylindrical surface**. This is achieved by rotating the work piece while the single point cutting tool removes the material by traversing in a direction parallel to the axis of rotation and termed as **turning**.

- **Centre lathe** is the most common of the lathes, which derives its name from the way a work piece is clamped by centres (live and dead centres) in a lathe, though this is not the only way in which the job is mounted.

- This is sometimes also called engine lathe in view of the fact that early lathes were driven by steam engines.



TYPICAL PARTS OF LATHE



TYPICAL PARTS OF LATHE

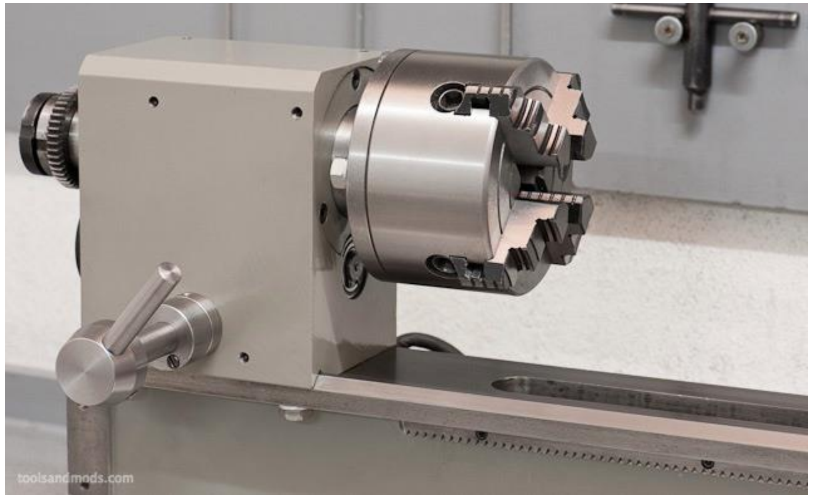
BED

- It’s the backbone of the lathe upon which all other components are mounted.
- The top of the bed is formed by guide ways. They act as a guide for accurate movement of carriage and tailstock.
- Made up of cast iron because of good damping and frictional resistance.

TYPICAL PARTS OF LATHE

HEADSTOCK (LIVE CENTRE)

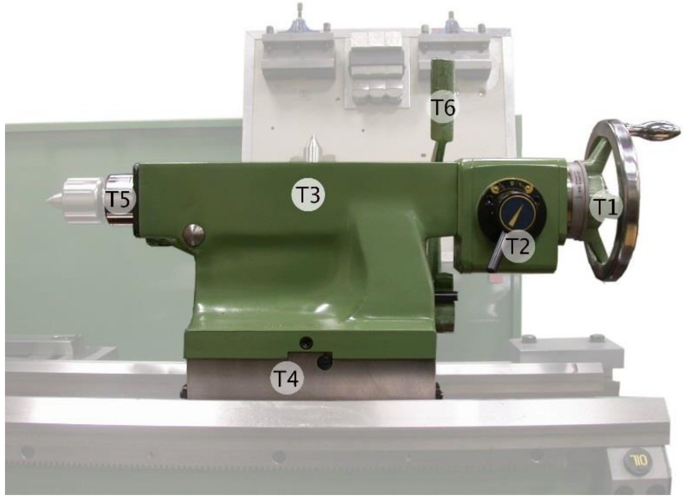
- Is a box like casting mounted at the left end of the machine.
- It contains feed gear box or cone pulley which enables the spindle to rotate at different speeds.
- The gear box distributes the power to the lead screw for threading or to the feed rod for turning.



TYPICAL PARTS OF LATHE

TAILSTOCK (DEAD CENTRE)

- It is mounted on the right side of the machine.
- It is the movable part of the lathe that carries the dead centre in it.
- It can be slided on the bed to support different length of work piece. It can be clamped on the bed at desired location.
- Can be moved laterally for taper turning
- It can be used to carry tool like drill, reamer for making hole.



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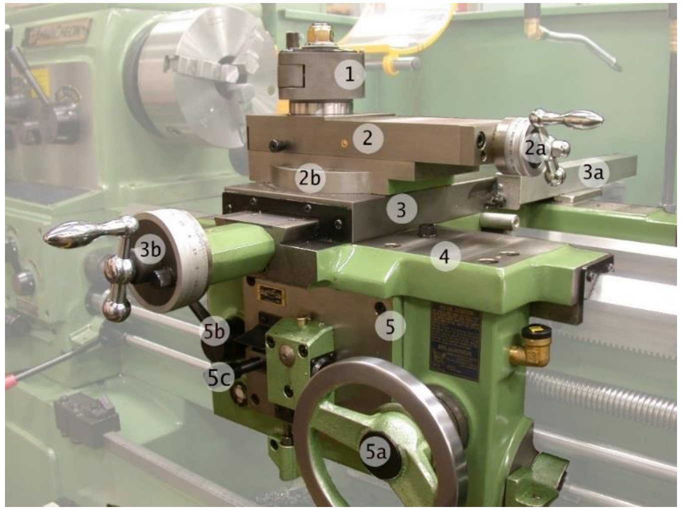
<u>TYPICAL PARTS OF LATHE</u>

<u>CARRIAGE ASSEMBLY</u>

- The carriage supports and feeds the tool against the work during the operation on the lathe.

- The carriage slides along the bed ways and consists of the following main parts -
  SADDLE
  CROSS SLIDE
  COMPOUND REST
  TOOL POST

- **<u>SADDLE</u>:** It is free to slide back and forth along the bed slide ways so that the tool will move parallel to the spindle axis.



TYPICAL PARTS OF LATHE

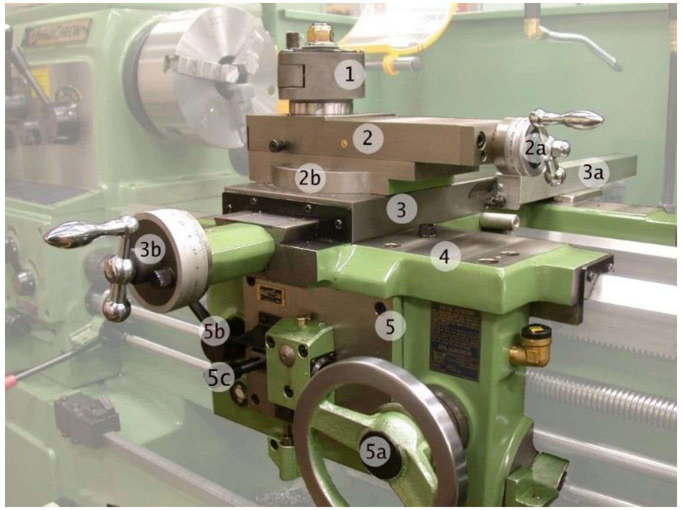
CARRIAGE ASSEMBLY

- **CROSS SLIDE:** On the upper surface of the saddle is the cross slide. This moves the tool at right angle to spindle axis.

- It can either be operated by the means of the cross slide hand wheel or may be given power feed through the apron mechanism.

- **COMPOUND REST:** The compound rest is mounted on the upper surface of the cross slide. This can be swiveled so that the tool can move at an angle to the spindle axis.

- **TOOL POST:** This is mounted on the compound rest and carries the cutting tool.



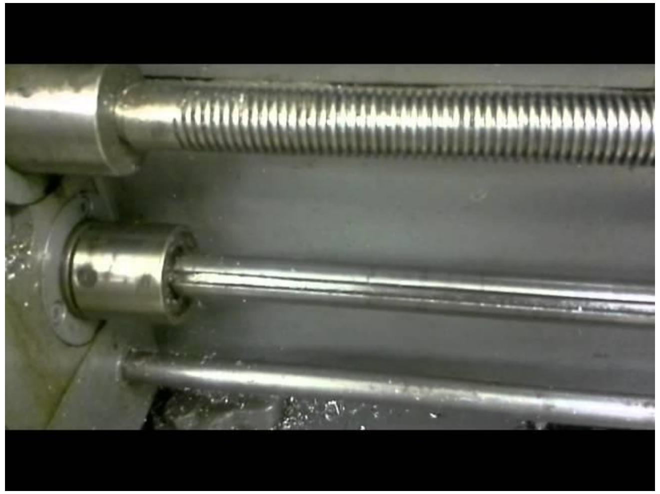
TYPICAL PARTS OF LATHE

FEED ROD

- Feed rod is long shaft used to drive the **apron mechanism** for cross and longitudinal power feed during turning. It is powered by the set of gears from the headstock.

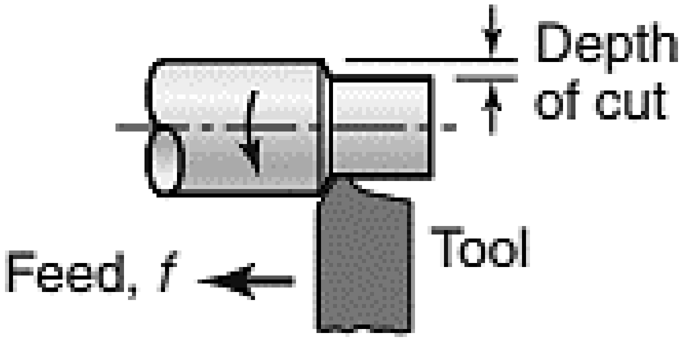
LEAD SCREW

- It is a long threaded shaft geared to the headstock. Closing a split nut around the lead screw engages it with the carriage. The lead screw is used for cutting thread accurately and should be disengaged for other operations.



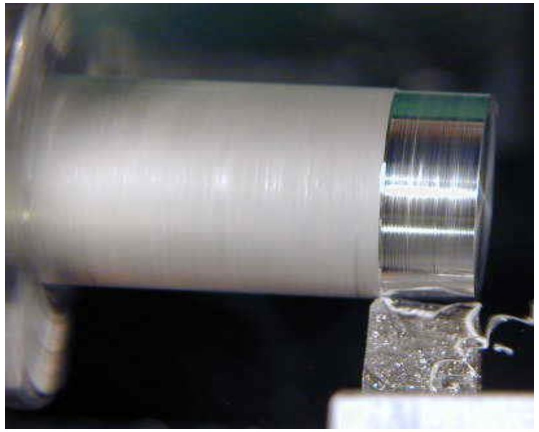
OPERATIONS ON LATHE

PLAIN TURNING



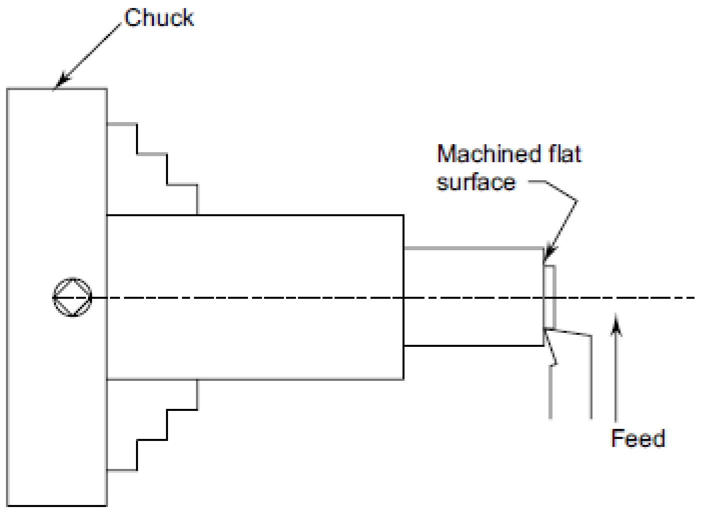
- Plain turning is by far the most commonly used operation in a lathe.

- In this the work held in the spindle is rotated while the tool is fed past the work piece in a direction parallel to the axis of rotation. The surface thus generated is the cylindrical surface as shown in Fig.



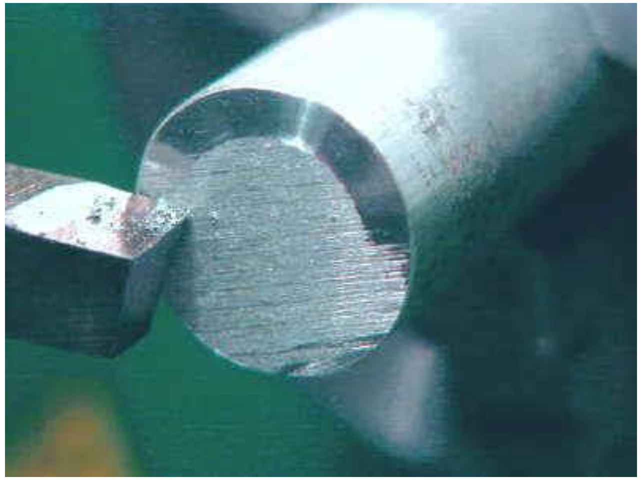
- It is usually done in two stages – rough turning and smooth or finish turning. **Rough turning** involves majority of material removal and it is usually done at high speeds while **smooth turning** is done at lesser speeds and it is involved in finishing the given job to required dimensions.

OPERATIONS ON LATHE



FACING

- Facing is an operation for generating flat surfaces in lathes.
- The feed in this case is given in a direction perpendicular to the axis of revolution.
- The tool used should have a suitable approach angle so that it would not interfere with the work piece during the tool feeding.



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OPERATIONS ON LATHE

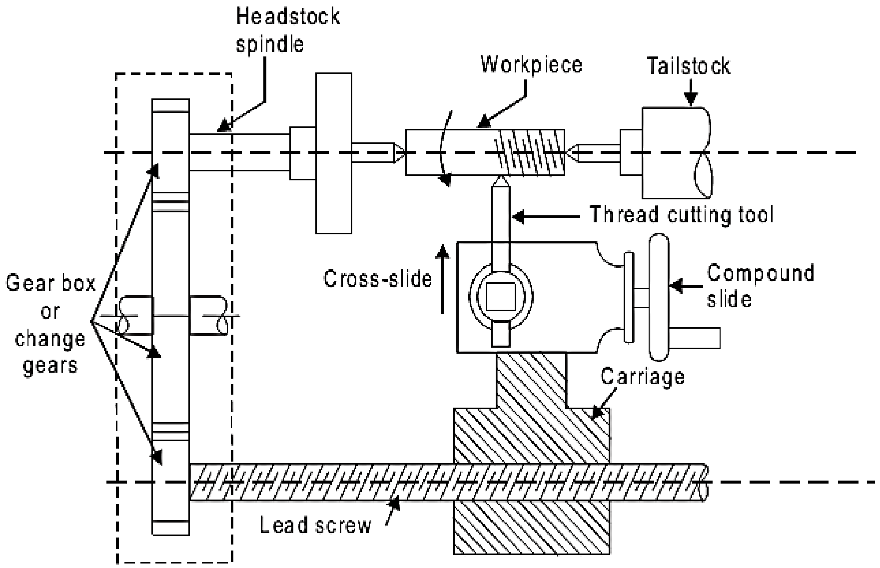
THREAD CUTTING

- A screw thread may be defined as a ridge of uniform cross section that follows a helical or spiral path on the outside or inside of a cylindrical surface.

- The cutting tool, the shape of which depends on the type of thread to be cut, is mounted on a holder and moved along the length of the workpiece by the lead screw on the lathe.

- This movement is achieved by the **engagement of a split nut (also called a half nut) inside the apron of the lathe.**

- The axial movement of the tool in relation to the rotation of the workpiece determines the pitch of the screw thread.



OPERATIONS ON LATHE

THREAD CUTTING

- The axial feed is automatically generated when cutting a thread by means of the lead screw, which drives the carriage. When the lead screw rotates a single revolution, the carriage travels a distance equal to the pitch of the lead screw.

- Consequently, if the rotational speed of the lead screw is equal to that of the spindle (that of the workpiece), the pitch of the resulting cut thread is exactly equal to that of the lead screw.

- The pitch of the resulting thread being cut, therefore, always depends upon the ratio of the rotational speeds of the lead screw and the spindle.

$$\frac{\text{Pitch of lead screw}}{\text{Desired pitch of workpiece}} = \frac{\text{rpm of workpiece}}{\text{rpm of lead screw}}$$

OPERATIONS ON LATHE

THREAD CUTTING

It is required to cut screw threads of 2 mm pitch on a lathe. The lead screw has a pitch of 6 mm. If the spindle speed is 60 rpm, then the speed of the lead screw will be

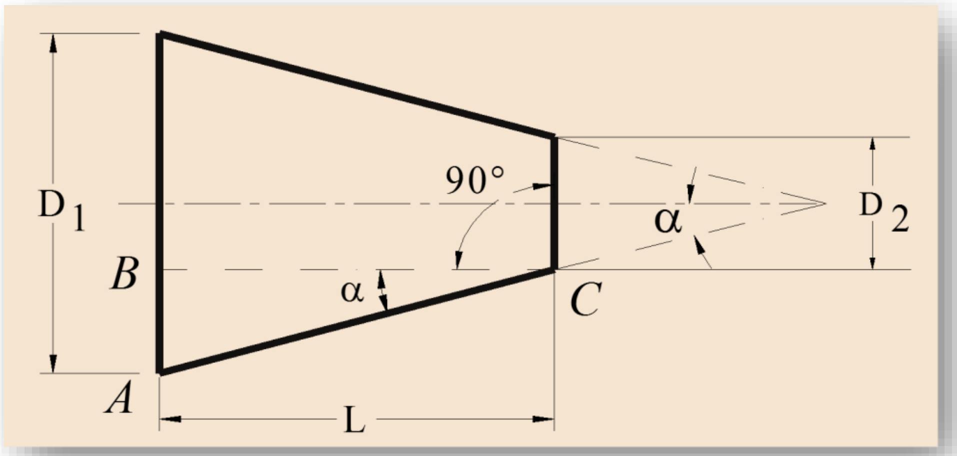
(A) 10 rpm (B) 20 rpm (C) 120 rpm (D) 180 rpm

OPERATIONS ON LATHE

TAPER TURNING

- Taper turning is the process of producing a conical surface from a cylindrical shaped workpiece.

- The taper to be produced is usually represented in terms of half taper angle.



$$\tan\alpha = \frac{D_1 - D_2}{2L}$$

OPERATIONS ON LATHE

TAPER TURNING

- A number of methods are available for cutting tapers in a lathe. They are:

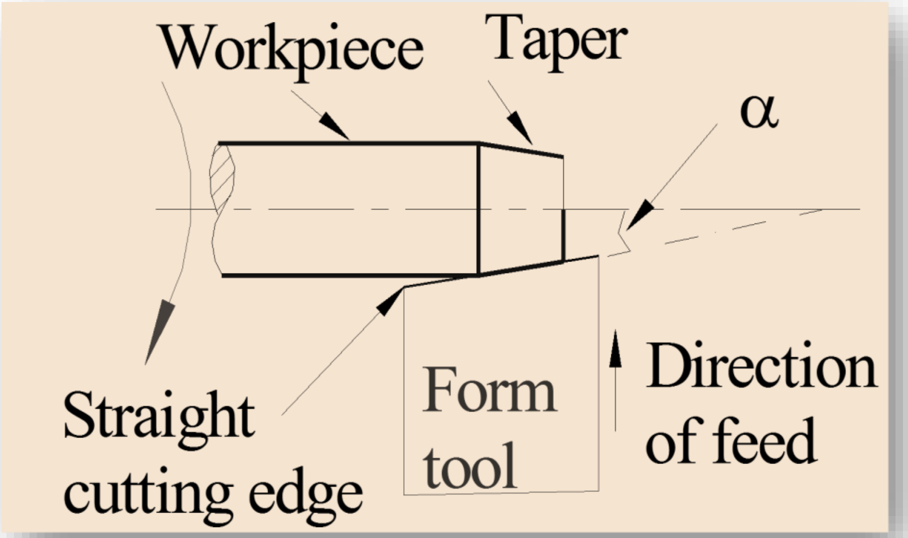
- **using form tools**
- **swivelling the compound rest**
- **offsetting the tailstock**
- **using taper turning attachment**

OPERATIONS ON LATHE

TAPER TURNING

Form tool method –

- A method that is normally used for production applications is the use of special form tool for generating the tapers.
- The feed is given by plunging the tool directly into the work. This method is useful for short tapers, where the steepness is of no consequence, such as for chamfering.



OPERATIONS ON LATHE

TAPER TURNING

Swivelling compound rest –

- It is possible to swivel the compound rest to the desired angle of the taper for cutting the tapers. The compound rest has a circular base graduated in degrees.

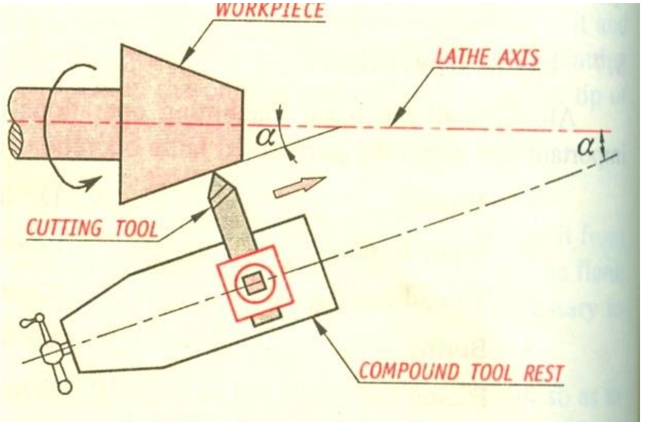
- The tool is then made perpendicular to the work piece and feed is given manually by the operator.

- Some of the features of this method are:

  ●Short and steep tapers can be easily done.

  ●Limited movement of the compound rest

  ●Feeding is by hand and is non-uniform. This is responsible for low productivity and poor surface finish.



Swiveling Compound Tool Rest

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OPERATIONS ON LATHE

TAPER TURNING

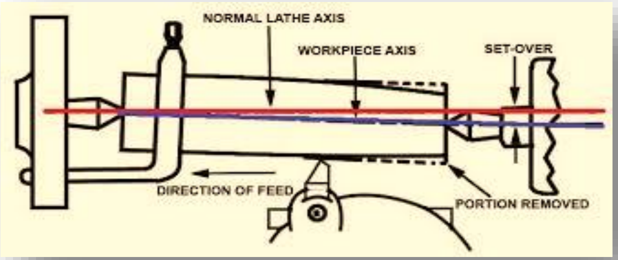
Offsetting the tailstock –

- Still another method sometimes used is the method of offsetting the tailstock from the centre position.

- By offsetting the tailstock, the axis of rotation of the job is inclined by the half angle of taper as shown in Figure.

- The feed to the tool is given in the normal manner parallel to the guideways. Thus the conical surface is generated. The offset that is possible is generally limited, and as such this method is suitable for small tapers over a long length.

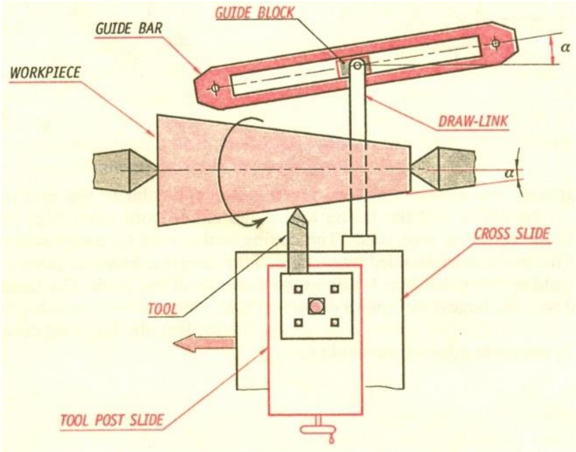
- The disadvantage is that the centres are not properly bearing in the centre holes and as such there would be non-uniform wearing taking place.



OPERATIONS ON LATHE

TAPER TURNING

Taper turning attachment method –



Taper Turning Attachment

- Still another method for turning tapers over a comprehensive range is the use of taper turning attachment.

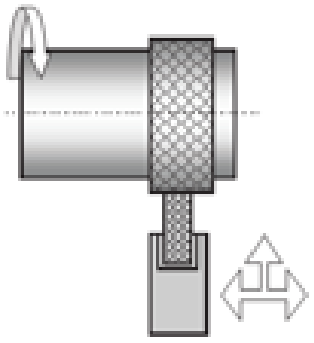
- In this method a separate slideway is arranged at the rear of the cross slide. This slide can be rotated at any angle to be setup. The block that can slide in this taper slide way is rigidly connected to the cross slide.

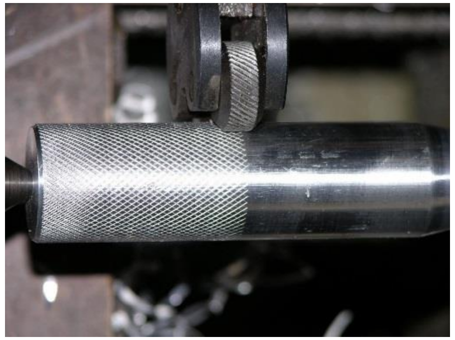
- As the carriage moves for feeding, the block moves in the inclined track of the slide, it gets the proportional cross movement perpendicular to the feed direction, the cross slide and in turn the cutting tool gets the proportional movement. Thus the tool tip follows the taper direction set in the attachment.

- This method is most commonly used for a range of tapers.

OPERATIONS ON LATHE

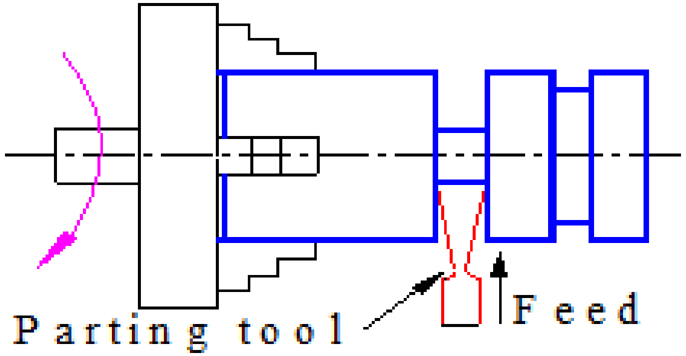
KNURLING





- Knurling is a metal working operation done in a lathe.
- In this a knurling tool having the requisite serrations is forced on to the work piece material, thus deforming the top layers. This forms a top surface, which is rough and provides a proper gripping surface.

PARTING



- Parting and grooving are similar operations. In this a flat nosed tool would plunge cut the work piece with a feed in the direction perpendicular to the axis of revolution. This operation is generally carried out for cutting off the part from the parent material.

WORK HOLDING DEVICE

- The most common form of work holding device used in a lathe is the **chuck**.
- Chucks come in various forms with a varying number of jaws. Of these the **three jaw chuck** or the **self-centering chuck** is the most common one.
- The main advantage of this chuck is the quick way in which the typical round job is centred. All the three jaws move radially inward or outward by the same amount.
- Thus, the jaws will be able to centre any job, whose external locating surface is cylindrical or symmetrical, like hexagonal.
- The independent jaw chuck has **four jaws**, which can be moved in their slots independent of each other, thus clamping any type of configuration. Since each of these jaws could move independently any irregular surface could be effectively centred.

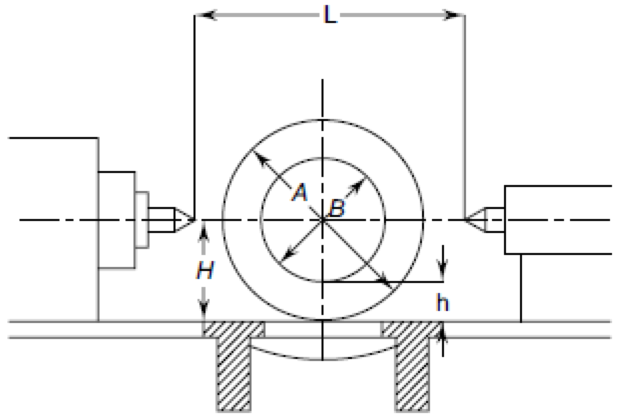
LATHE SPECIFICATIONS

➢ In order to specify a lathe, a number of parameters could be used based on the specific application. The following are the basic elements generally specified for the capability of the lathe machine.

● Distance between centres (L) —this specifies the maximum length of the job that can be turned in the lathe.

● Swing over the bed (H) —this specifies the maximum diameter of the job (A) that can be turned in the lathe machine, generally restricted to small length jobs.

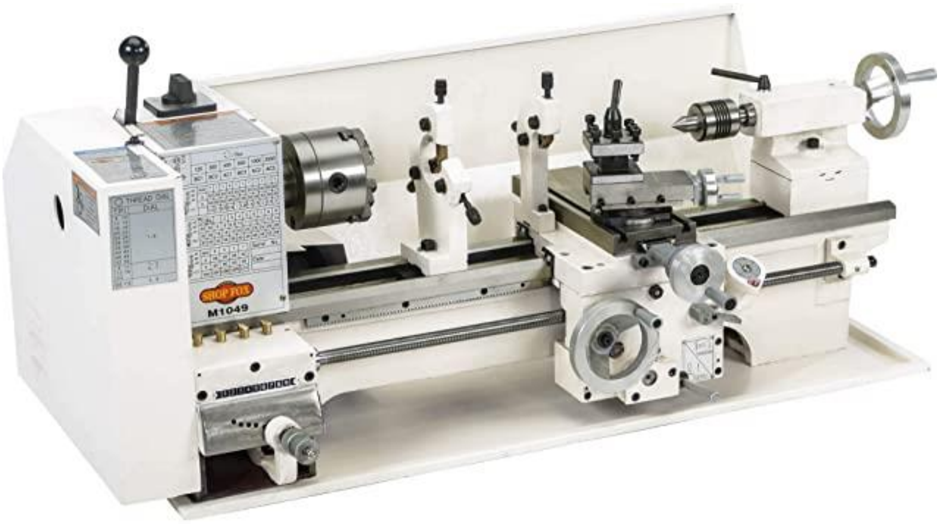
● Swing over the cross slide (H-h) —this specifies the maximum diameter of the job (B) that can be turned in the lathe machine with the job across the cross slide, which is generally the case.



TYPES OF LATHE

BENCH LATHE

- The name bench lathe is given to a small centre lathe that is mounted on a workbench.
- In design it has the same features as centre lathes and differs only in size and mounting.
- It is adapted to small work, having a maximum swing capacity of 255mm (10"). Bench lathe is used for small precision work like instrument parts.



TYPES OF LATHE

CAPSTAN AND TURRET LATHE

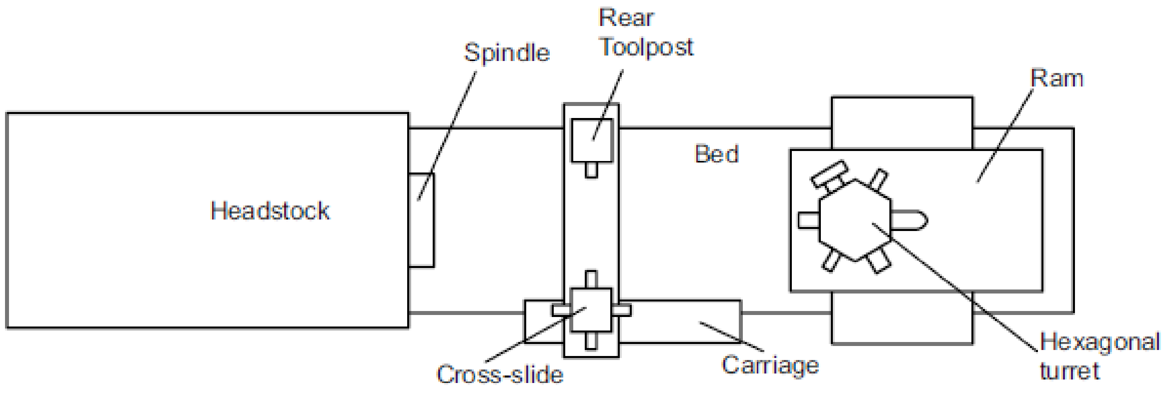
- The main characteristic feature of the capstan and turret lathes is the six sided (hexagonal) block mounted on one end of the bed replacing the normal tailstock. This allows for mounting six tool blocks each of which can contain one or more tools depending upon the requirement.

- Further on the cross slide, two tool posts are mounted, one in the front and the other in the rear. Each one of them can hold up to four tools each. Thus, the total carrying capacity is a maximum of 14 tools when only one tool is mounted in each of the locations.

- The turret is mounted on a saddle, which in turn is sliding on the bed. When the saddle moves on the bed during the return stroke it would automatically be indexed to the next tool position, thus reducing the idle time of the machine.

TYPES OF LATHE

CAPSTAN AND TURRET LATHE



CAPSTAN LATHE

TURRET LATHE

TYPES OF LATHE

GAP LATHE

- It is used for machining large work with irregular protrusions. On this lathe, a section of bed, adjacent to the headstock can be removed to machine a large size workpiece.

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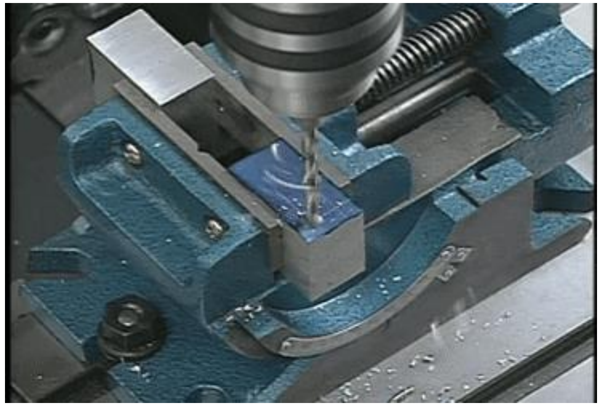
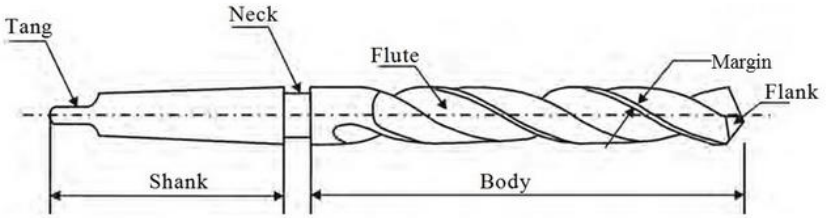
DRILLING



- Drilling is the operation of making primarily a hole in a workpiece using a drill bit.
- The stationary work is held in a fixture and rotating tool is fed vertically to make a circular hole.



- The cutting tool used for making holes in solid material is called the **twist drill**.
- It basically consists of two parts; the body consisting of the cutting edges and the shank which is used for holding purpose. This has two cutting edges and two opposite spiral **flutes** cut into its surface.

- These flutes serve to provide clearance to the chips produced at the cutting edges. They also allow the cutting fluid to reach the cutting edges.

DRILLING MACHINES

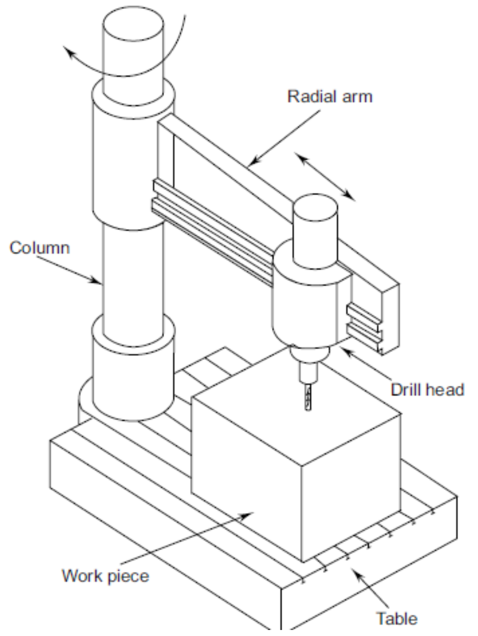
RADIAL DRILLING MACHINE

GANG DRILLING MACHINE

Radial Drilling Machine

- The drill head can move along the radial arm to any position while the radial arm itself can rotate on the column, thus reaching any position in the radial range of the machine.

- They are more convenient to be used for large work pieces, which cannot be moved easily because of their weight, such that the drill head itself will be moved to the actual location on the work piece, before carrying the drilling operation.



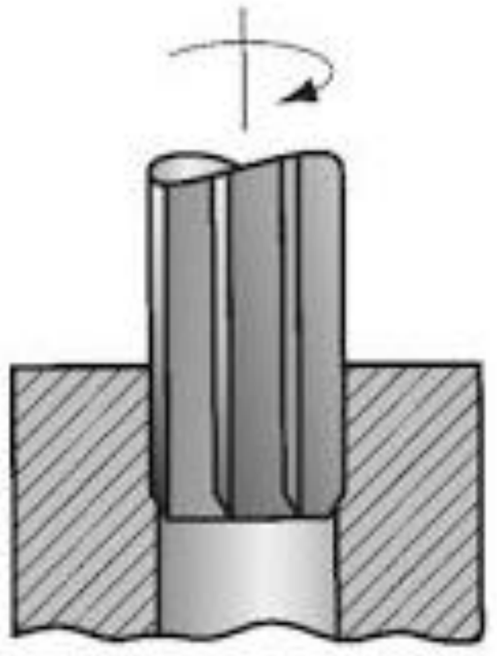
Gang Drilling Machine

- Gang drilling machines have a number of spindles (often equal to four) laid out in parallel. Each of the spindles can have different drills or other hole making operation tools fixed in sequence.

- These are used for volume production with the work pieces located in a jig.

Types of Drilling Machines

Reaming



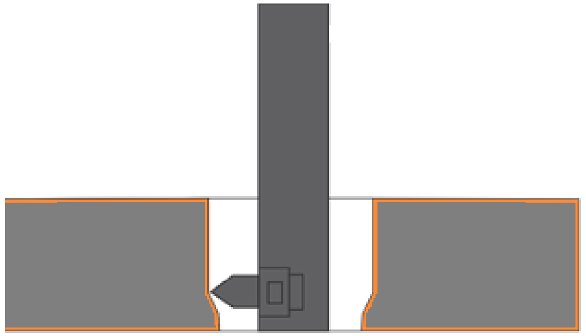
- Reaming is the operation of finishing a previously drilled hole to bring it to a more exact size and to improve the surface finish of the hole.

- The operation is carried out using a multi tooth revolving tool called reamer which consists of a set of parallel straight or helical cutting edges along the length of the cylindrical body.

- While reaming, the speed of the spindle is reduced to nearly half of that of drilling.

Types of Drilling Machines

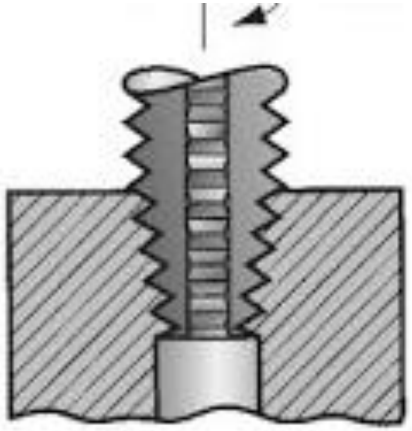
Boring



- Boring is an operation of enlarging a hole.
- The single point cutting tool used for boring operations is mounted in the boring bar of suitable diameter commensurate with the diameter to be bored.
- **Sizing**: Boring brings the hole to the proper size and finish. A drill or reamer can only be used if the desired size is **"standard"**. The boring tool can work to any diameter and it will give the required finish by adjusting speed and feed.
- In addition to enlargement, boring operation corrects the hole loctation and out of roundness, if any, as the tool can be adjusted to remove more metal from one side of the hole than the other.

Types of Drilling Machines

Tapping



➢ A faster way of producing internal threads in a previously drilled hole is by the use of tapping operation.

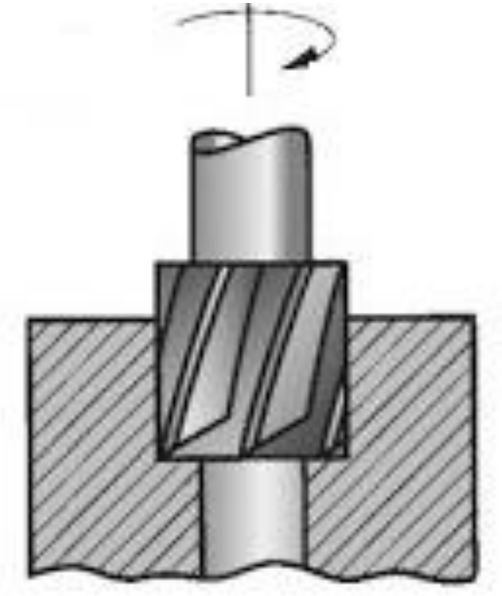
➢ A tap is a multi fluted cutting tool with cutting edges on each blade resembling the shape of threads to be cut. A tap of the required size is to be used after carrying out the pre-drilling operations. The tapping drill sizes for ISO metric threads are usually available in standard tables.

➢ While tapping, care has to be taken to see that the tap is started in proper alignment with the hole.

➢ Sometimes it may become necessary to reverse the tap slightly to break the chips and clear the chip space and then continue in the normal way.

Types of Drilling Machines

Counter boring

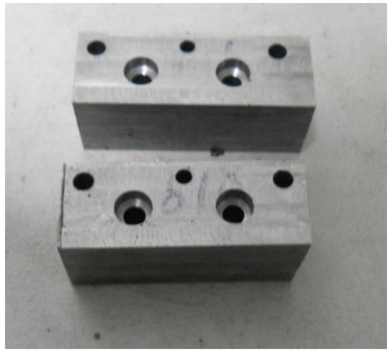


- In the counter boring operation, the hole is enlarged with a flat bottom to provide proper seating for the bolt head or a nut, which will be flush from the outer surface.

- The counter boring can be done by a tool with the cutting edges present along the side as well as the end, while a pilot portion is present for the tool to enter the already machined hole to provide the concentricity with the hole.

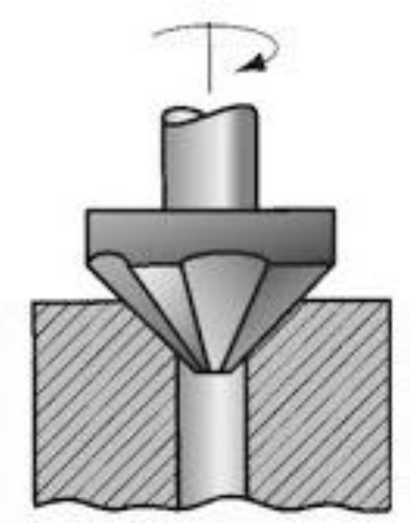
- The pilot should fit snugly in the hole and should have sufficient clearance facilitating the free movement of the tool.

- Generally the speeds and feeds used for counter boring are slightly smaller than those used for the corresponding drilling operation.



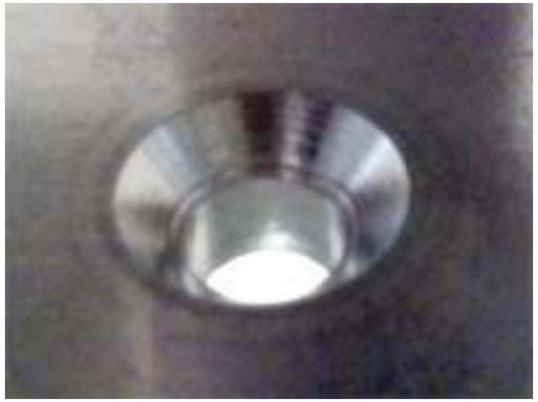
Types of Drilling Machines

Counter sinking



- Counter sinking is also similar to counter boring; except that the additional machining done on a hole is conical to accommodate the counter sunk machine screw head.

- Again the depth of counter sinking should be large enough to accommodate the screw head fully flush with the surface.



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Chapter 1 – Machining Processes

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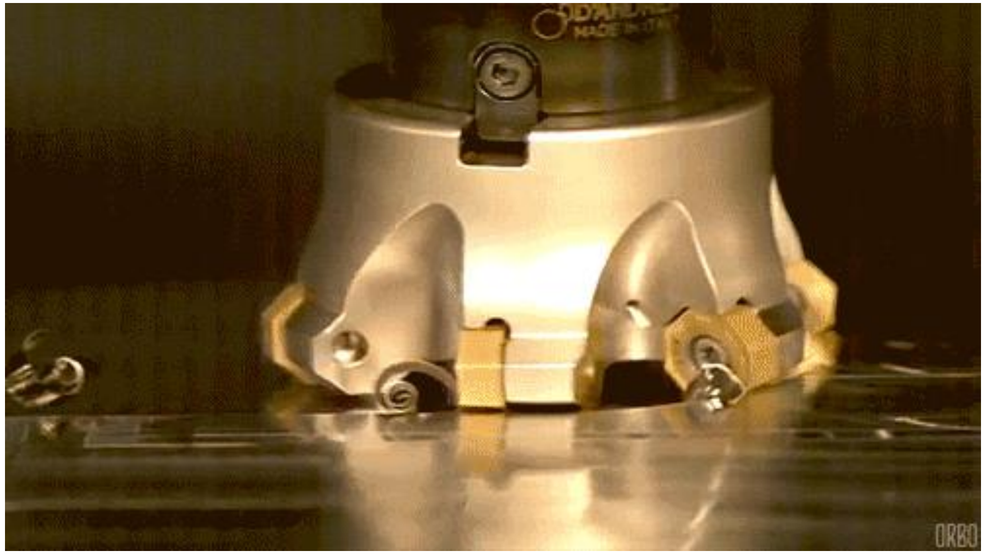
MILLING

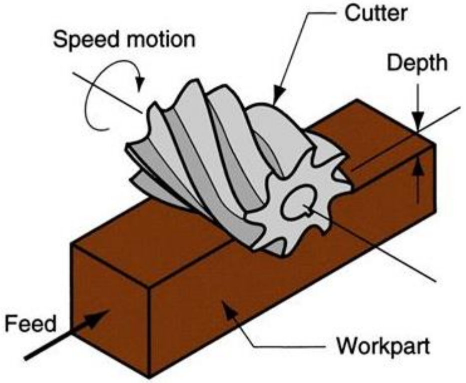
- In milling, the work piece is fed into a rotating milling cutter, which is a multi-point tool as shown.

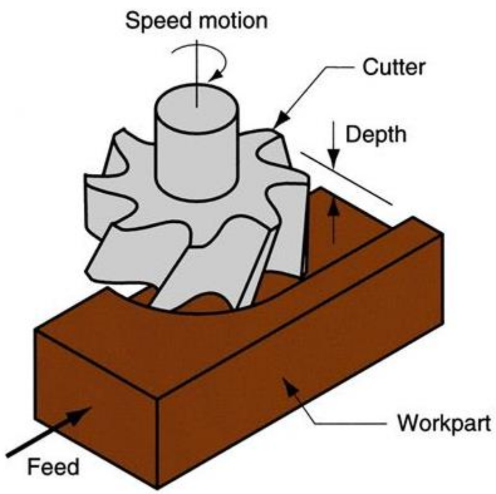
- It is unlike a lathe, which uses a single point cutting tool. The tool used is called milling cutter.



MILLING

- Milling operation can be classified into two broad categories: **Peripheral Milling, Face Milling.**
- In peripheral milling the surface generated is **parallel** with the axis of rotation of cutter. This type of milling is carried out in Horizontal milling machine.
- In face milling surface generated is **at right angle** to the cutter axis. This type of milling is carried out in Vertical milling machine.





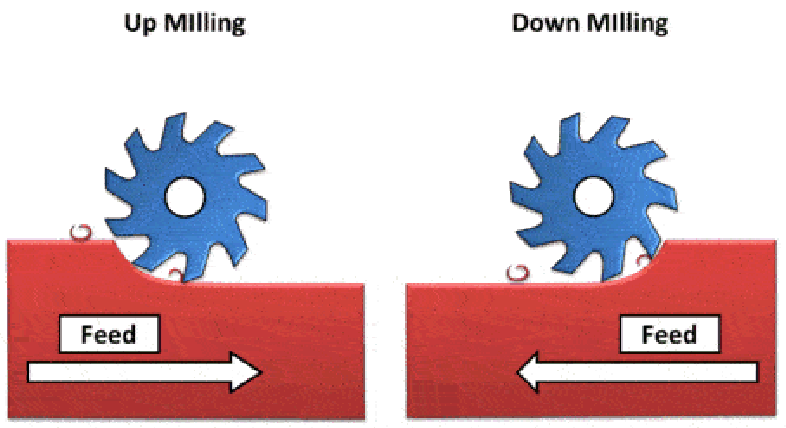
UP AND DOWN MILLING

- Based on the directions of movement of the milling cutter and the feeding direction of the work piece, there are two possible types of milling:

● **Up milling (conventional milling)**
● **Down milling (Climb milling)**

- In up milling the cutting tool rotates in the **opposite direction** to the table movement. This tends to lift the work piece from the table.

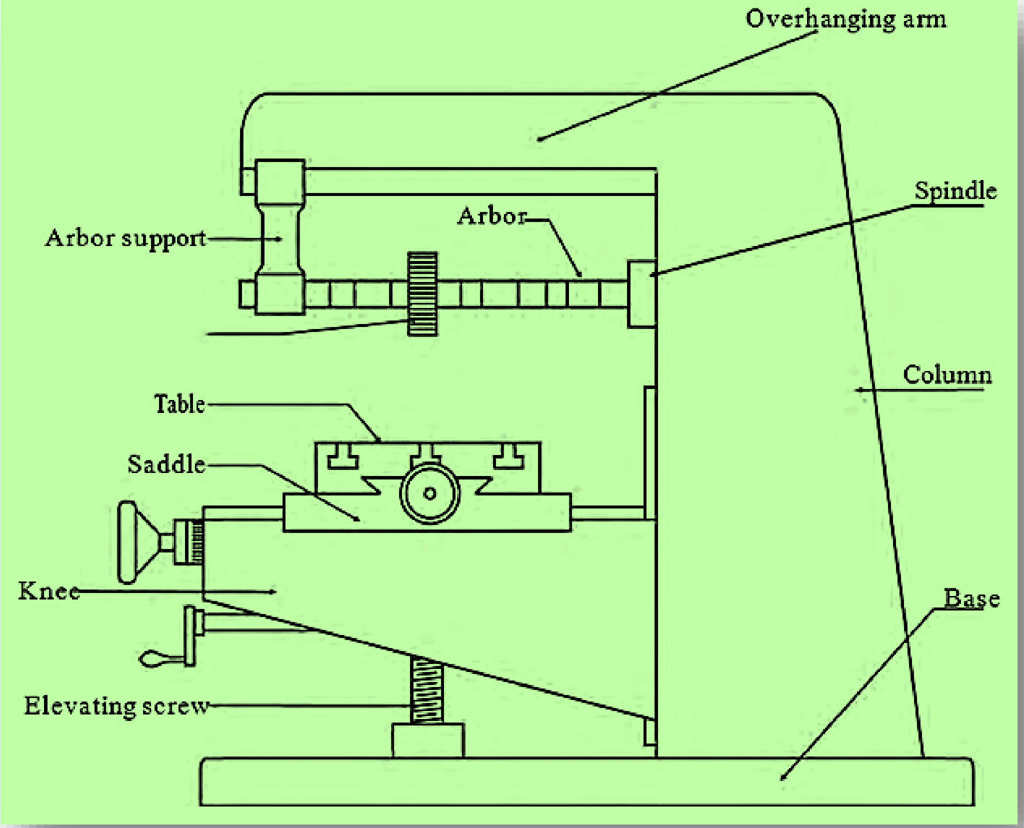
- In down milling the cutting tool rotates in the **same direction** as that of the table movement. The cutting force will act downwards and as such would keep the work piece firmly in the work holding device.



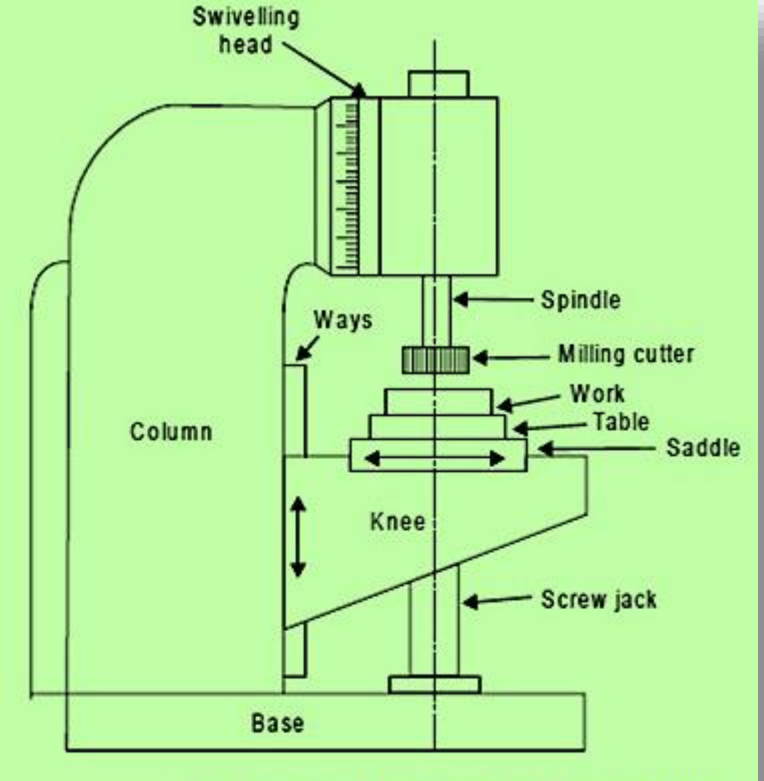
UP AND DOWN MILLING

UP MILLING	DOWN MILLING
In up milling cutter rotates against the direction of feed	Cutter rotates with the direction of feed
In this process, heat is diffused to the work piece which causes the change in metal properties	In down milling most of the heat diffuse to the chip without change the work piece properties
Progressive chip formation	Chip size is maximum at start and decreases with the feed

HORIZONTAL MILLING MACHINE



VERTICAL MILLING MACHINE



A column and knee type milling machine

Sl No.	HORIZONTAL MILLING MACHINE	VERTICAL MILLING MACHINE
1	Spindle is horizontal and parallel to the worktable	Spindle is vertical and perpendicular to the worktable
2	Cutter cannot be moved up and down	Cutter can be moved up and down
3	Cutter is mounted on the arbor	Cutter is directly mounted on the spindle
4	Spindle cannot be tilted	Spindle can be tilted for angular cutting
5	Operation such as plan milling, gear cutting, form milling, straddle, gang milling etc.., can be performed	Operation such as slot milling, T- slots, flat milling and also different drilling operations can be performed

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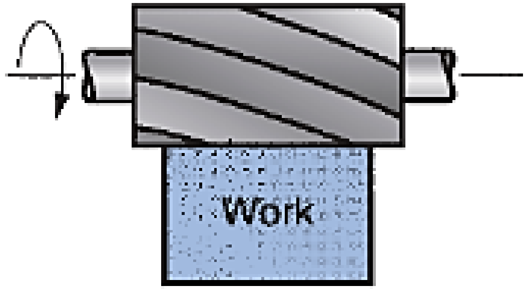
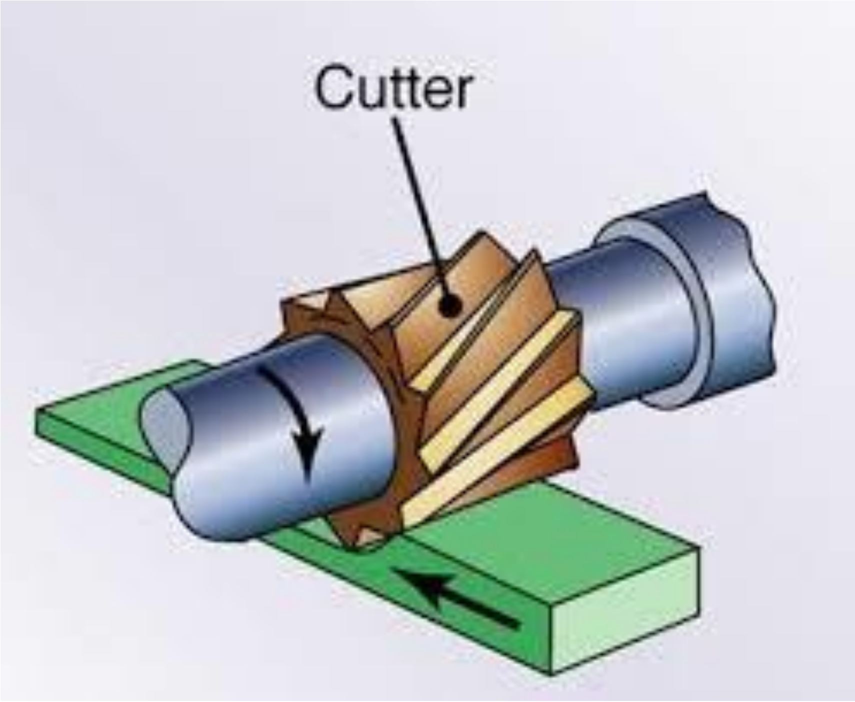
MILLING OPERATIONS

SLAB MILLING

- The basic form of peripheral milling in which the cutter width extends beyond the workpiece on both sides.

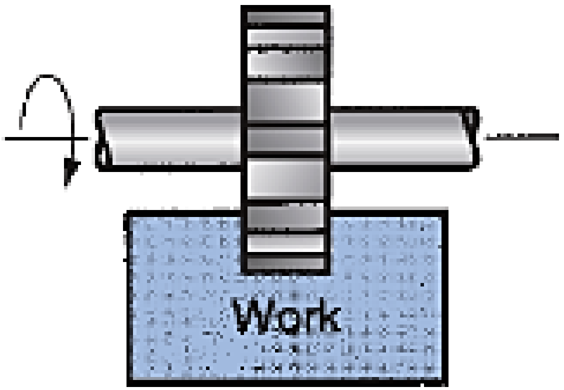




MILLING OPERATIONS

SLOTTING

- Here the width of the cutter is less than the workpiece width, creating a slot in the work (when the cutter is very thin, this operation can be used to mill narrow slots).

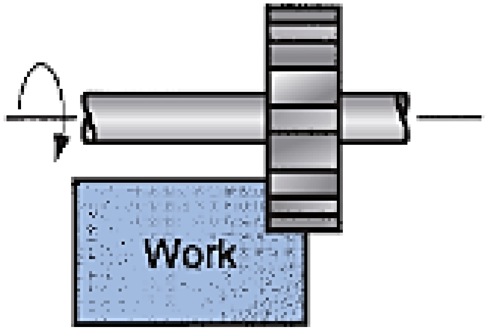


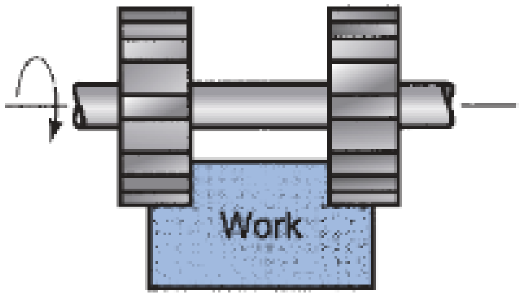
MILLING OPERATIONS

SIDE AND STRADDLE MILLING

- **Side milling** – Cutter machines the side of the workpiece.

- **Straddle milling** – It is same as side milling, but cutting takes place on both sides of the work.

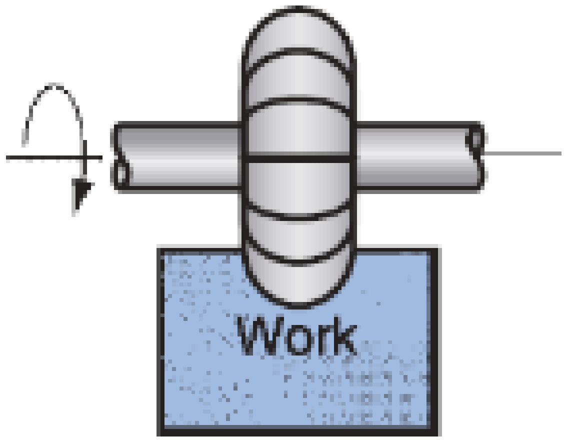




MILLING OPERATIONS

FORM MILLING

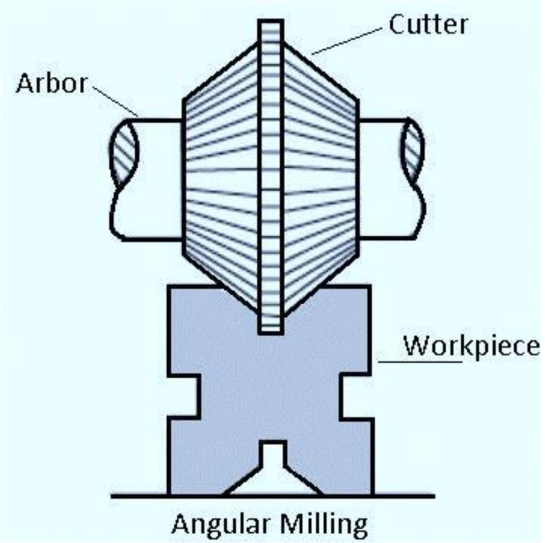
- The milling teeth have a special profile that determines the shape of the slot that is cut in the work.



MILLING OPERATIONS

ANGULAR MILLING

- Its operation of producing angular surface on the workpiece. A single or double cutter can be used to produce shapes like V grooves in the V- blocks



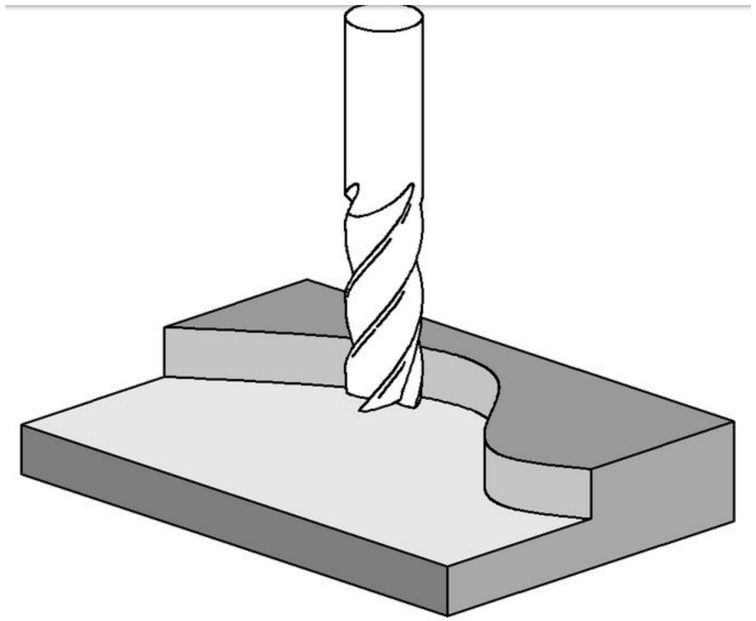
MILLING OPERATIONS

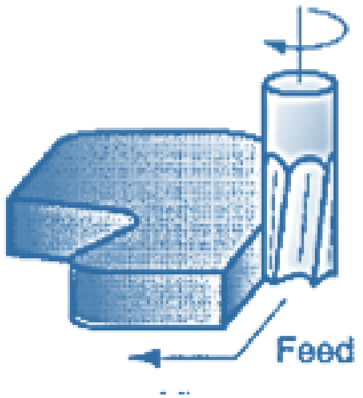
END MILLING

- End milling is the operation performed for producing flat surfaces, slots, grooves or finishing the edges of the workpiece by means of a tool called ***end mill*** or ***end milling cutter***.

- The cutter has teeth on the end as well as the periphery (sides) and hence can be configured to cut with both its end and the sides.

- **Profile milling** – It is a form of end milling done on the perimeter of a workpiece and can produce nearly any shape that has interior radii at least as large as that of the cutter.

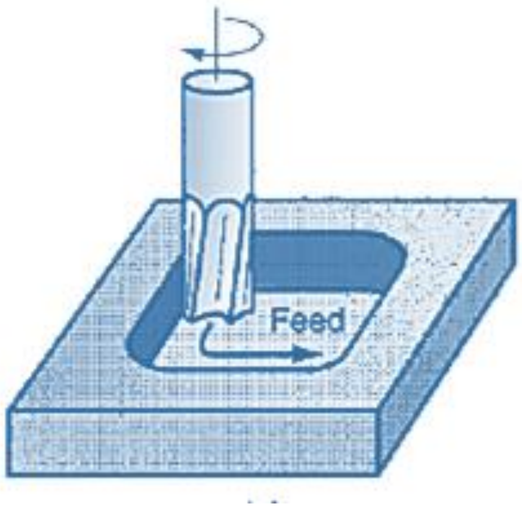


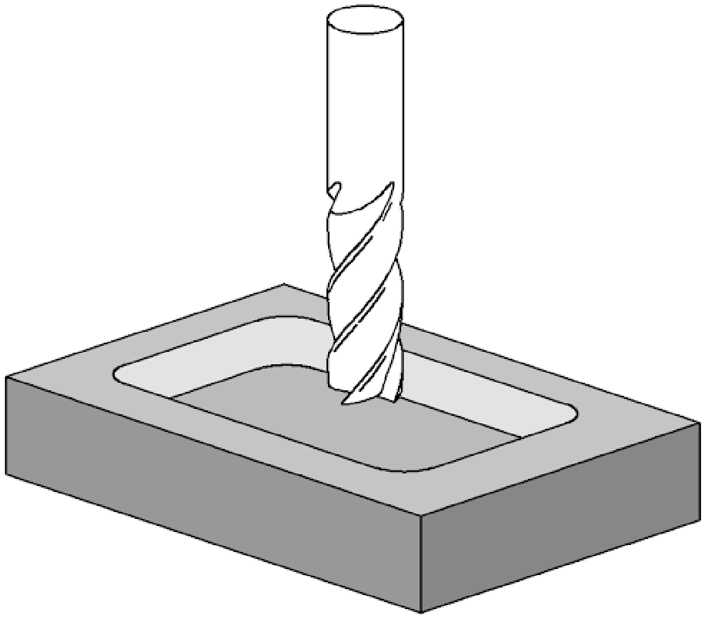


MILLING OPERATIONS

END MILLING

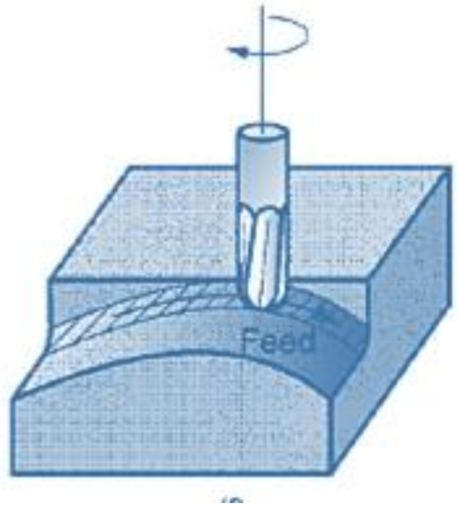
➢ **Pocket Milling** - Another form of end milling used to mill shallow pockets into flat parts.





MILLING OPERATIONS

END MILLING



- **Surface Contouring** - A ball-nose cutter (rather than square-end cutter) is fed back and forth across the work along a curvilinear path at close intervals to create a three-dimensional surface form.

- Contouring can be used to produce tooling such as injection molds and forming dies.

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INTRODUCTION TO INDUSTRIAL ROBOTICS

- An industrial robot is a general purpose, programmable machine possessing certain ***anthropomorphic characteristics.***

- The most obvious anthropomorphic characteristic of an industrial robot is its mechanical arm, that is used to perform various industrial tasks.

- Other human like characteristics are the robot's capability to respond to sensory inputs, communicate with other machines and make decisions. These capabilities permit robots to perform a variety of useful tasks.

Reasons for the commercial and technological importance of industrial robots include the following –

1) Robots can be substituted for humans in **hazardous or uncomfortable work environments**.

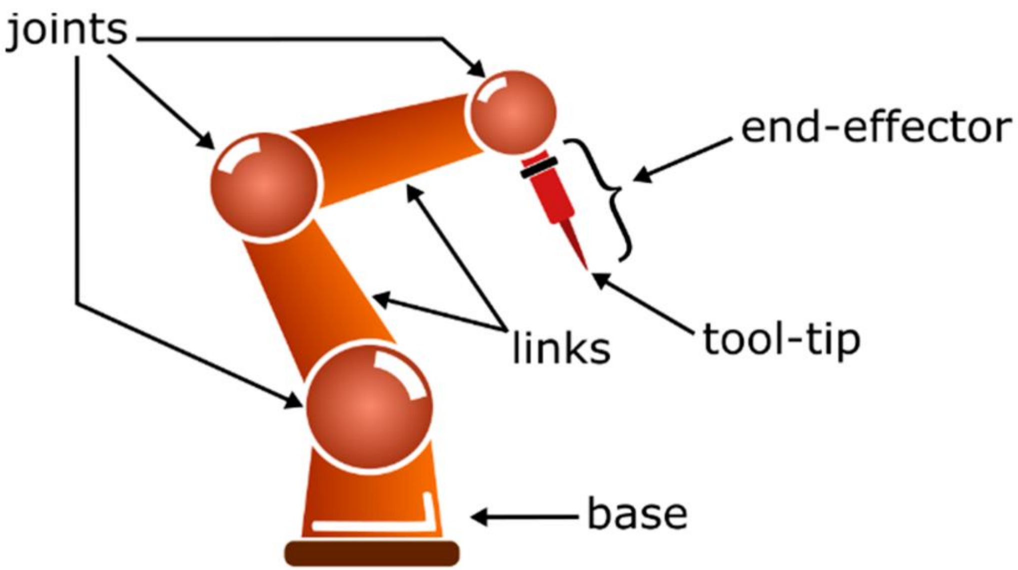
2) A robot performs its work cycle with a **consistency and repeatability** that cannot be attained by humans.

3) Robots can be **reprogrammed**. When the production run of the current task is completed, a robot can be reprogrammed and equipped with necessary tooling to perform an altogether different task.

4) Robots are controlled by computers and can therefore be connected to other computer systems to achieve **computer integrated manufacturing**.

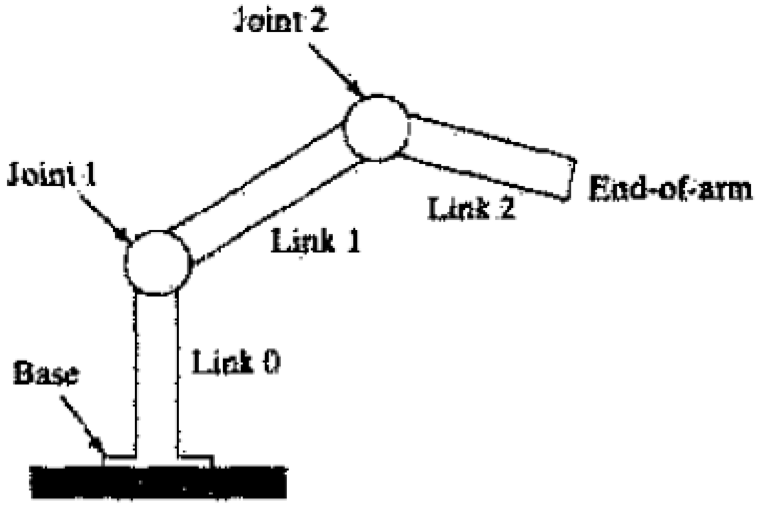
Robot Anatomy

- The manipulator of an industrial robot is constructed of **a series of joints and links**. Robot anatomy is concerned with the types and sizes of these joints and links and other aspects of the manipulator's physical construction.



Joints and Links

- A joint of an industrial robot is similar to a joint in the human body. It provides relative motion between two parts of the body.
- Connected to each joint are two links, **an input link and an output link**. Links are the rigid components of the robot manipulator.
- The purpose of the joint is to provide controlled relative movement between the input link and the output link.



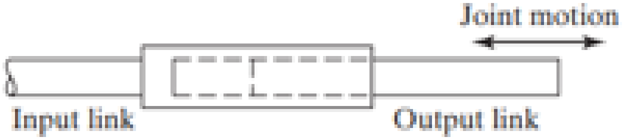
Most robots are mounted on a stationary base on the floor. Let us refer to that base and its connection to the first joint as link 0. It is the input link to joint 1, the first in the series of joints. The output link of joint 1 is link 1. Link 1 is the input link to joint 2, whose output link is link 2 and so forth.

Types of Joints

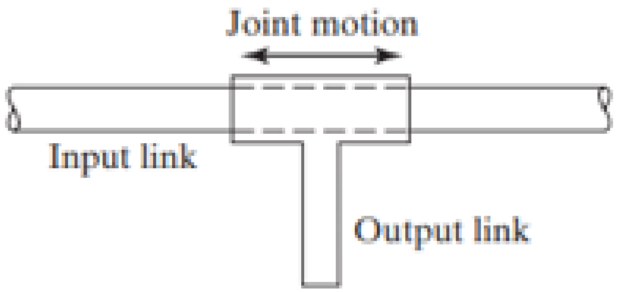
- Nearly all industrial robots have mechanical joints that can be classified into one of five types: two types that provide translational motion and three types that provide rotary motion. The five joints are:

- **Rotational joint**
- **Linear joint**
- **Twisting joint**
- **Orthogonal joint**
- **Revolving joint**

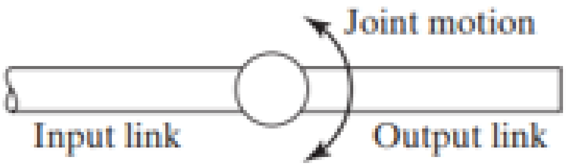
Types of Joints

JOINT	DESCRIPTION	SCHEMATIC
Linear joint	Type L joint; the relative movement between the input link and the output link is a translational sliding motion, with the axes of the two links parallel	

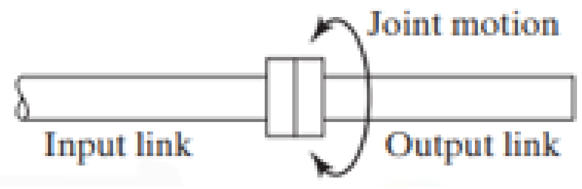
Types of Joints

JOINT	DESCRIPTION	SCHEMATIC
Orthogonal joint	Type O joint; the relative movement between the input link and the output link is a translational sliding motion, but the output link is perpendicular to the input link	

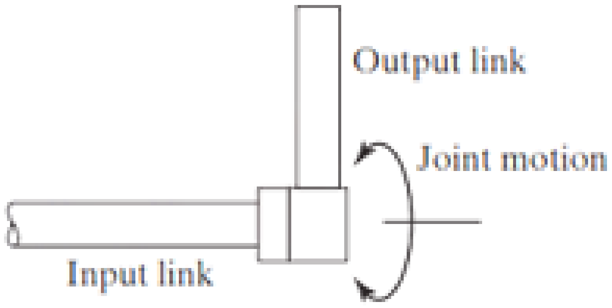
Types of Joints

JOINT	DESCRIPTION	SCHEMATIC
Rotational joint	Type R joint; this provides rotational relative motion, with the axis of rotation perpendicular to the axes of the input and output links	

Types of Joints

JOINT	DESCRIPTION	SCHEMATIC
Twisting joint	Type T joint; this provides rotary motion, but the axis of rotation is parallel to the axes of the two links	

Types of Joints

JOINT	DESCRIPTION	SCHEMATIC
Revolving joint	Type V joint; the axis of the input link is parallel to the axis of rotation of the joint, and the axis of the output link is perpendicular to the axis of rotation	

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Robot Configurations

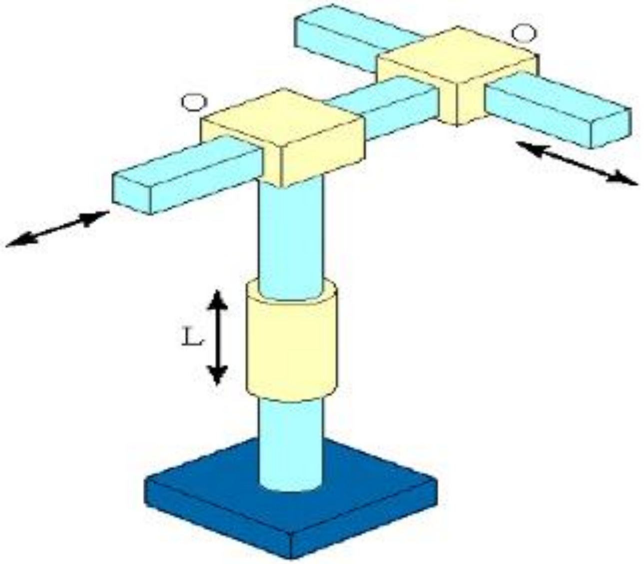
- A robot manipulator can be divided into two sections: a **body and arm assembly** and a **wrist assembly.**

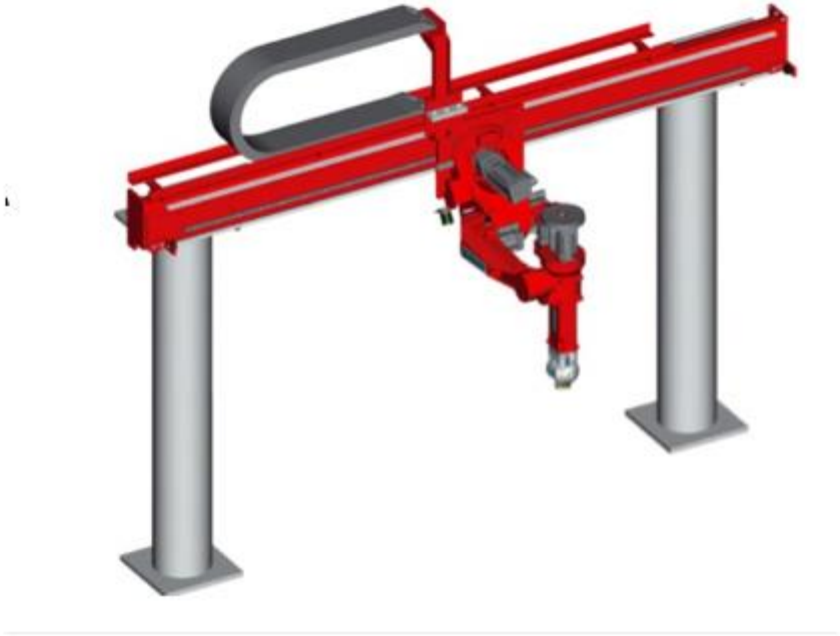
- At the end of the manipulator's wrist is a device related to the task that must be accomplished by the robot. The device called an **end effector** is usually either
  (1) a gripper for holding a work part
  (2) a tool for performing some process.

- The body and arm of the robot is used to position the end effector and the robot's wrist is used to orient the end effector.

Body and Arm Configurations

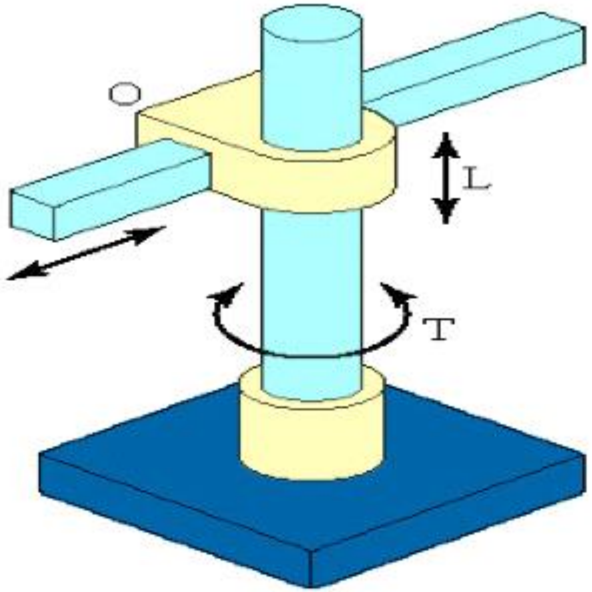
Cartesian coordinate robot – Other names for this configuration include rectilinear robot and x – y – z robot. As shown in Figure, it is composed of three sliding joints, two of which are orthogonal.





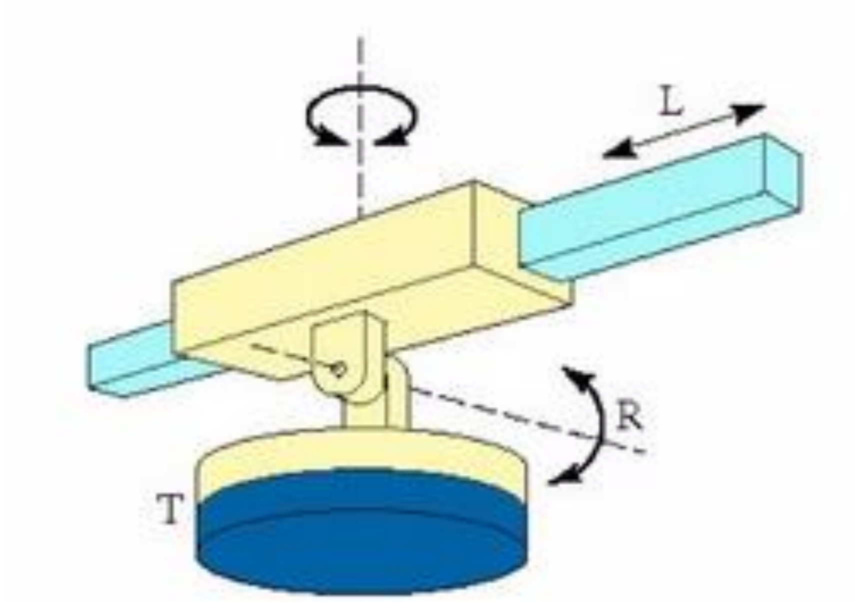
Body and Arm Configurations

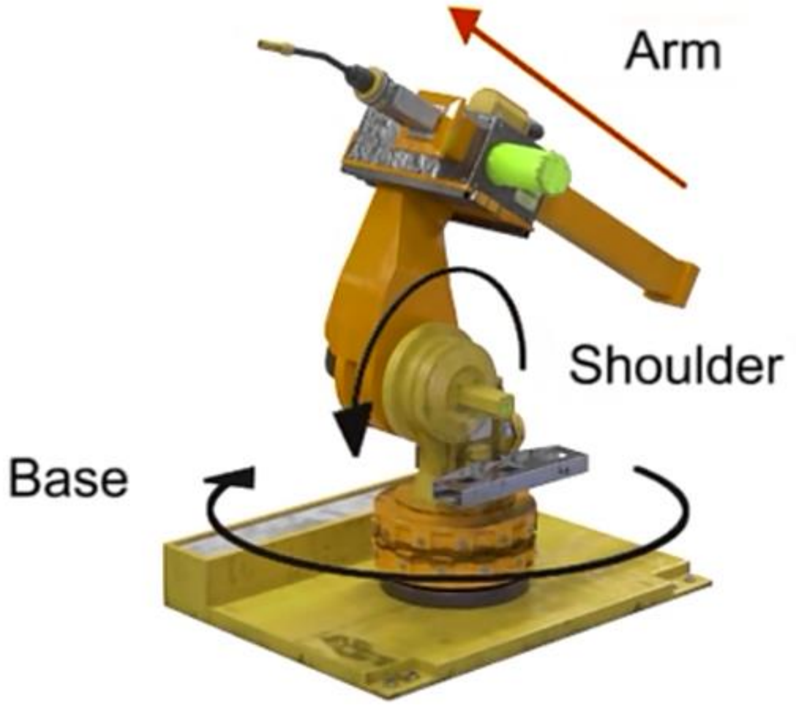
Cylindrical configuration – This robot configuration consists of a vertical column, relative to which an arm assembly is moved up or down. The arm can be moved in and out relative to the axis of the column. The column can be rotated about it’s axis.



Body and Arm Configurations

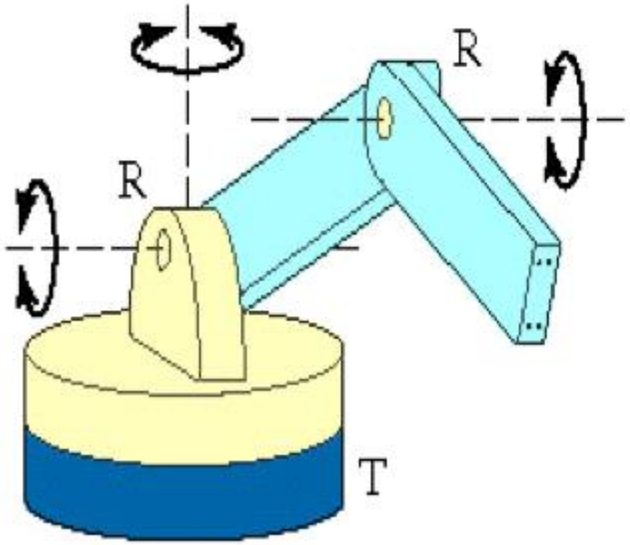
Polar configuration – This configuration consists of a sliding arm (L joint) actuated relative to the body, that can rotate about both a vertical axis (T joint) and a horizontal axis (R joint).





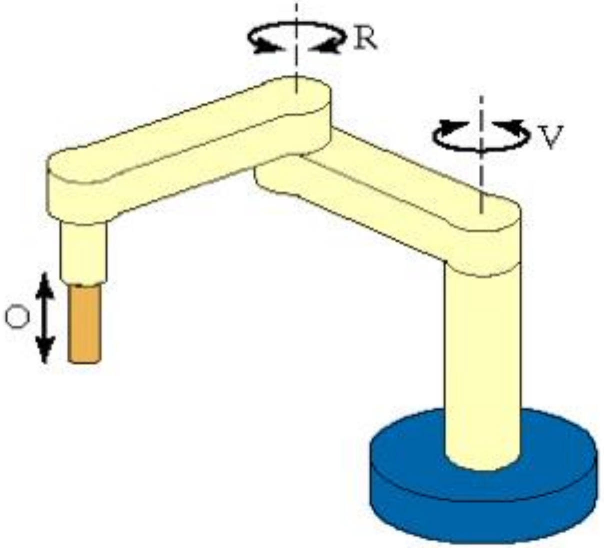
Body and Arm Configurations

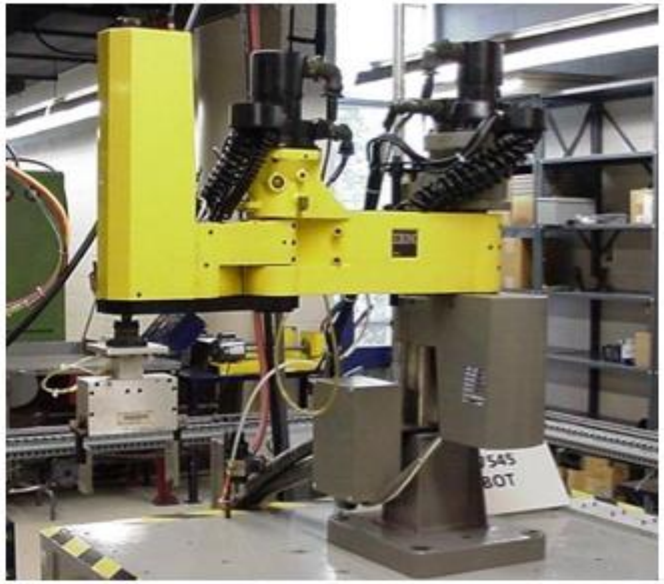
Jointed arm robot – This robot manipulator has the general configuration of a human arm. The jointed arm consists of a vertical column that swivels about the base using a T joint. At the top of the column is a shoulder joint (shown as an R joint in the figure), whose output link connects to an elbow joint (another R joint).



Body and Arm Configurations

SCARA – SCARA is an acronym for Selective Compliance Assembly Robot Arm. This configuration is similar to the jointed arm robot except that the shoulder and elbow rotational axes are vertical, which means that the arm is very rigid in the vertical direction, but compliant in the horizontal direction. This permits the robot to perform insertion tasks (for assembly) in a vertical direction, where some side to side alignment may be needed to mate the two parts properly.



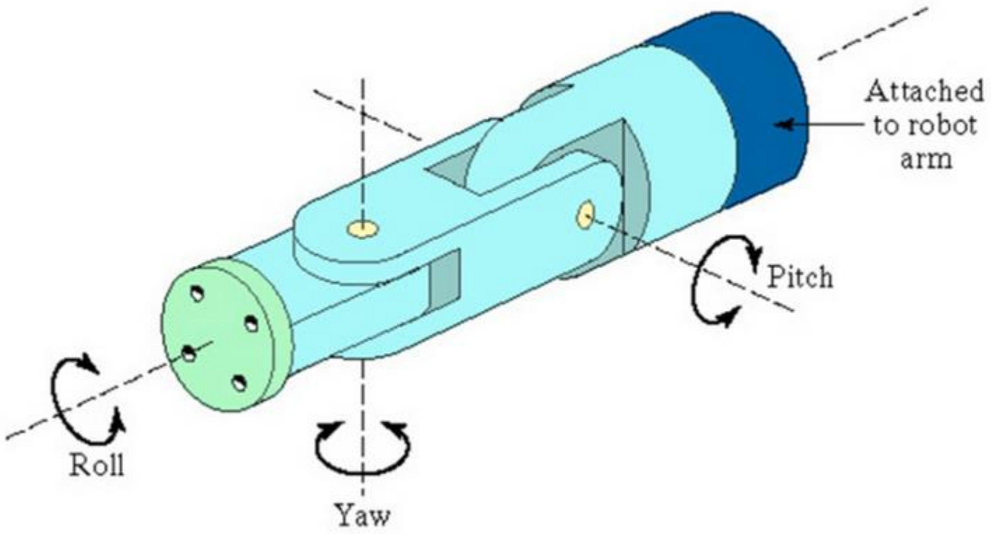


Wrist Configurations

- The robot's wrist is used to establish the orientation of the end effector.

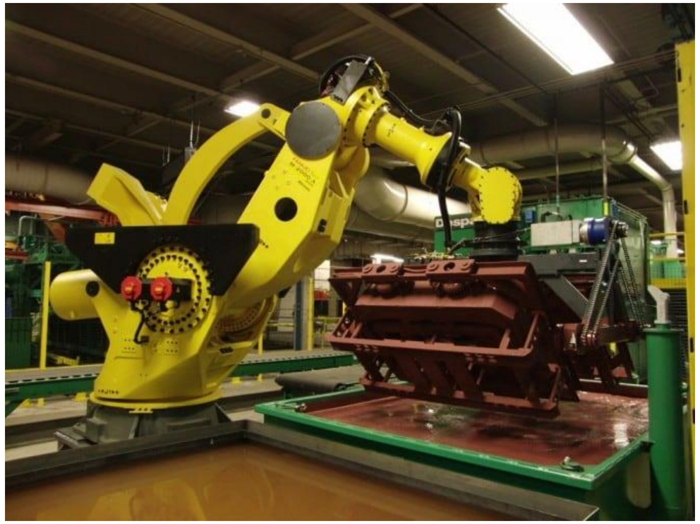
- The three joints are defined as:

1) **Roll**, using a T joint to accomplish rotation about the robot's arm axis
2) **Pitch**, which involves up and down rotation, typically using a R joint
3) **Yaw**, which involves right and left rotation, also accomplished by means of a R - joint.



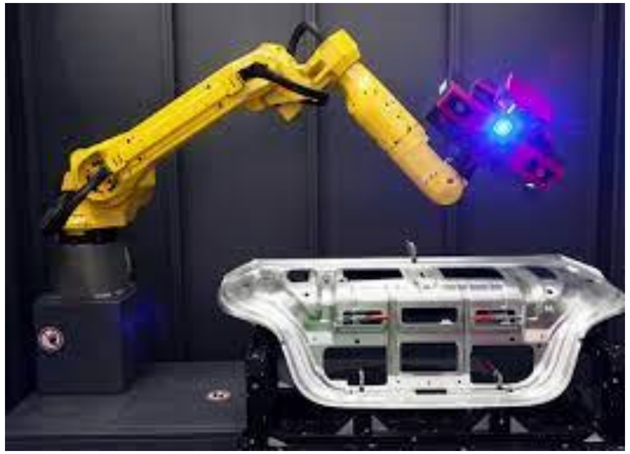
Applications

- Material handling applications –
  1) Material transfer
  2) Machine loading and/or unloading



- Processing Operations – Spot welding, Continuous arc welding, Spray painting etc.

- Assembly and Inspection



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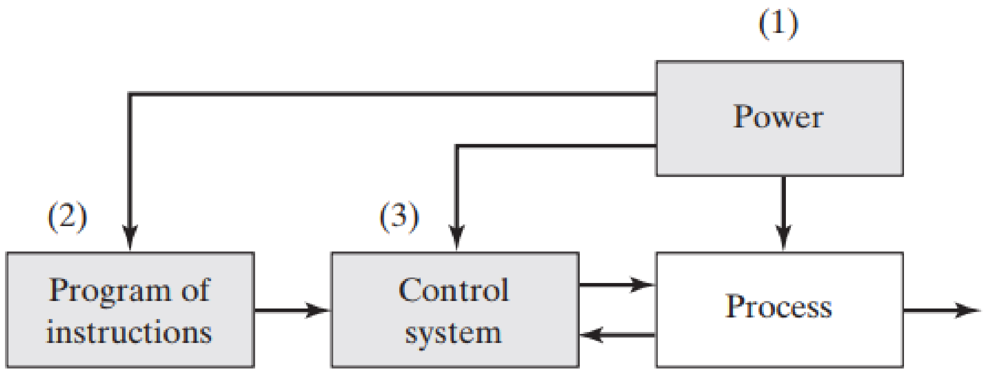
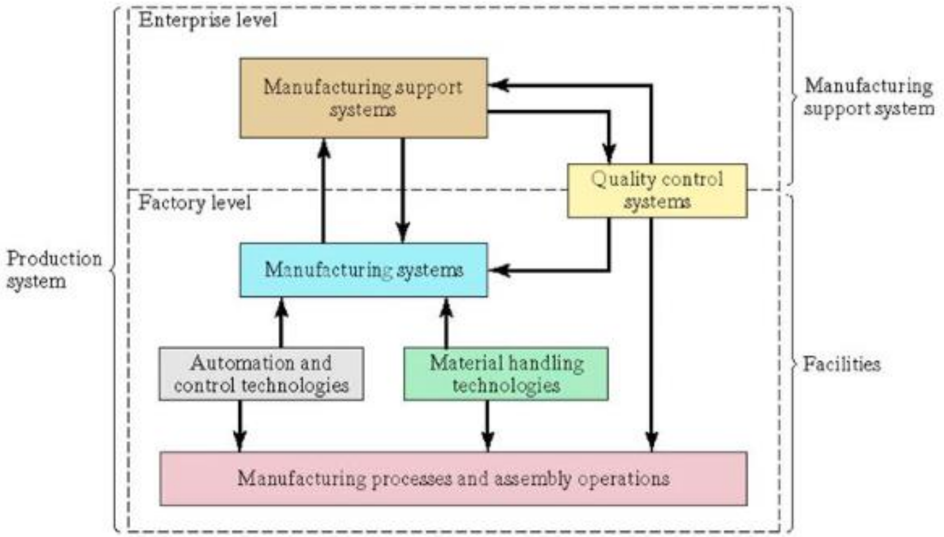
INTRODUCTION TO AUTOMATION

- **Automation is the technology by which a process or procedure is accomplished without human assistance.**

- It is implemented using a **program of instructions** combined with a **control system** that executes the instructions. To automate a process, **power** is required, both to drive the process itself and to operate the program and control system.

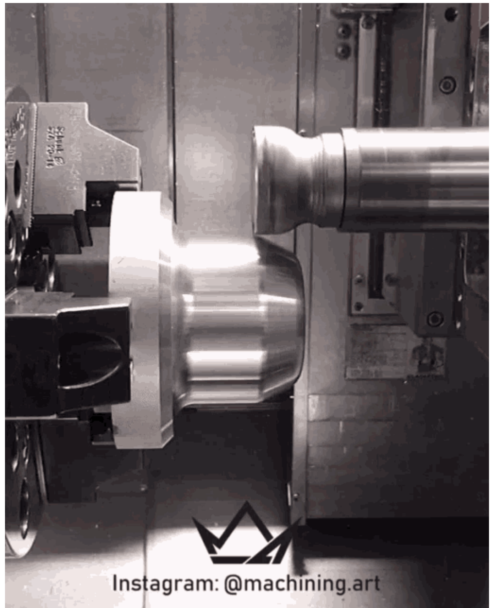
- Although automation can be applied in a wide variety of areas, it is most closely associated with the **manufacturing industries**.





EXAMPLES OF AUTOMATED MANUFACTURING SYSTEMS

- Automated machine tools that process parts
- Transfer lines that perform a series of machining operations
- Automated assembly systems
- Manufacturing systems that use industrial robots to perform processing or assembly operations
- Automatic material handling and storage systems to integrate manufacturing operations
- Automatic inspection systems for quality control



TYPES OF AUTOMATED MANUFACTURING SYSTEMS

Fixed Automation

- **Fixed automation is a system in which the sequence of processing (or assembly) operations is fixed by the equipment configuration.**

- Each of the operations in the sequence is usually simple, involving perhaps a plain linear or rotational motion or an uncomplicated combination of the two.

- Typical features: **high initial investment, high production rates, relatively inflexible in accommodating product variety.**

- **Examples – machining transfer lines and automated assembly machines.**

TYPES OF AUTOMATED MANUFACTURING SYSTEMS

Programmable Automation

- **In *programmable automation*, the production equipment is designed with the capability to change the sequence of operations to accommodate different product configurations.**

- The operation sequence is controlled by a program, which is a set of instructions coded so that they can be read and interpreted by the system.

- New programs can be prepared and entered into the equipment to produce new products.

- Typical features**: high investment in general purpose equipment; lower production rates than fixed automation; flexibility to deal with variations and changes in product configuration; most suitable for batch production**

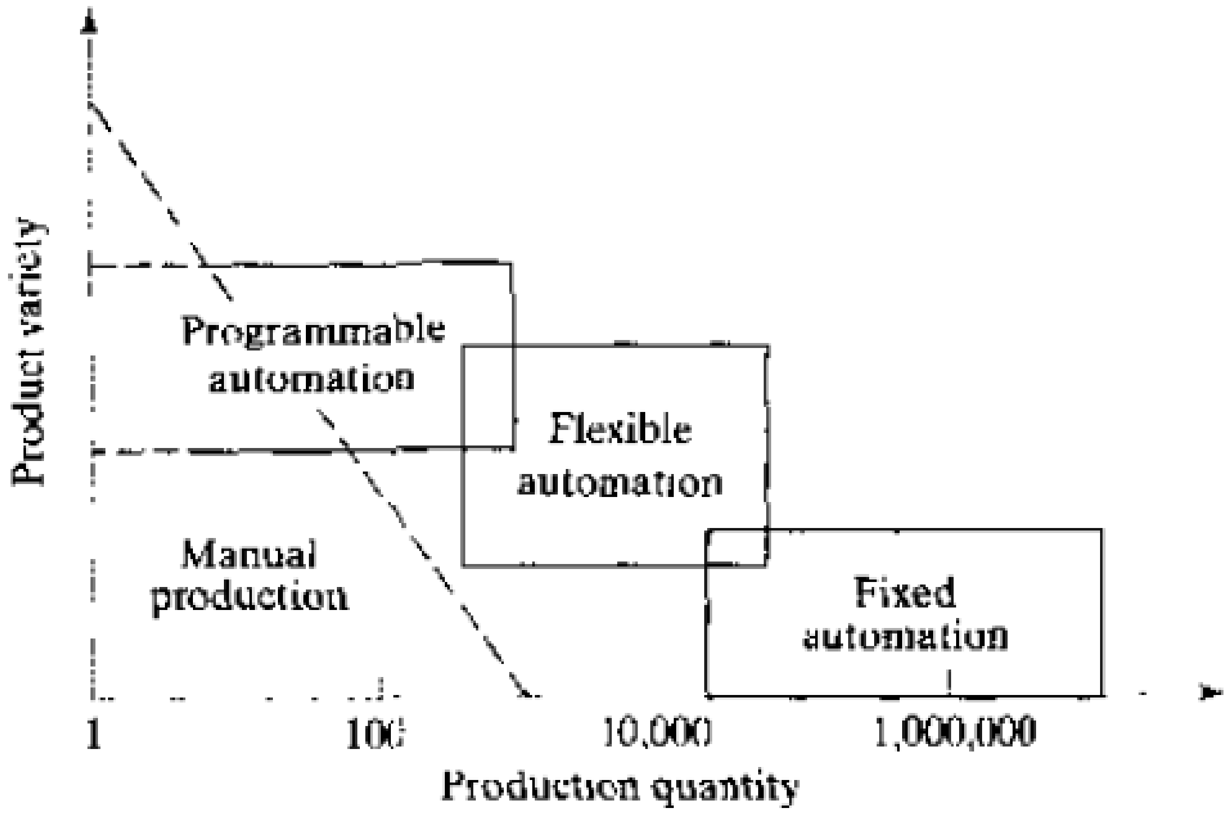
- **Examples – CNC machine tools, industrial robots etc.**

TYPES OF AUTOMATED MANUFACTURING SYSTEMS

Flexible Automation

- Flexible automation is an extension of programmable automation.
- **A flexible automated system is capable of producing a variety of parts with virtually no time lost for changeovers from one part style to the next.**
- There is no lost production time while reprogramming the system and altering the physical setup. Consequently the system can produce various combinations of parts or products instead of requiring that they be made in batches.
- What makes flexible automation possible is that the differences between parts processed by the system are not significant.
- Typical features: **high investment for a custom engineered system; continuous production of variable mixtures of products; medium production rates; flexibility to deal with product design variations**

TYPES OF AUTOMATED MANUFACTURING SYSTEMS



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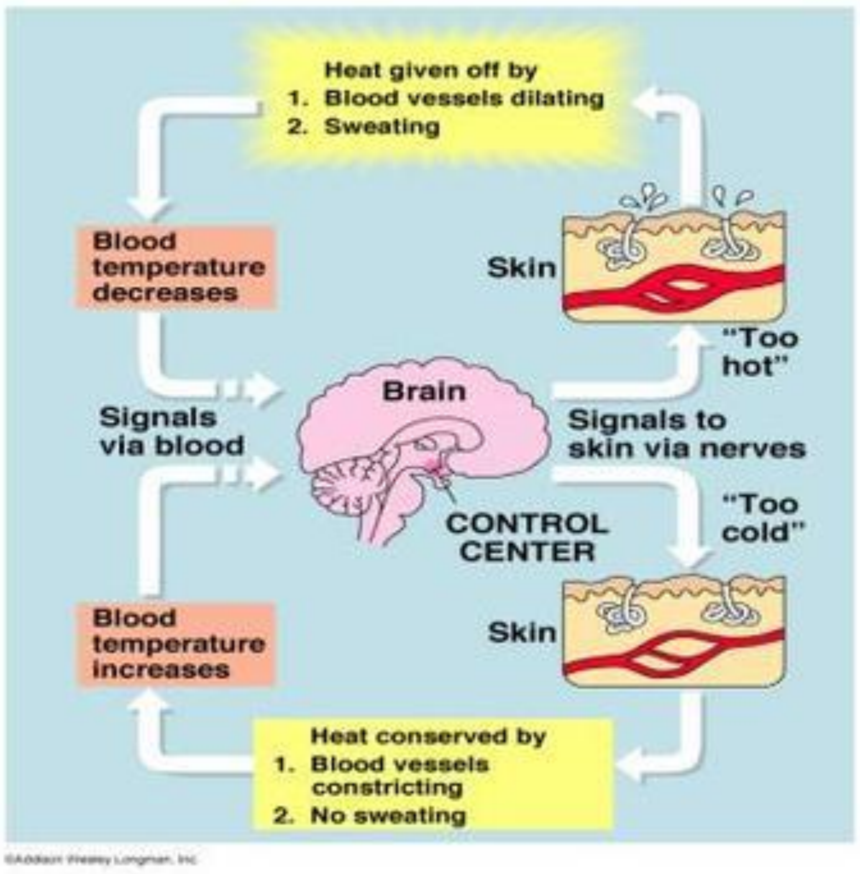
INTRODUCTION TO CONTROL SYSTEMS

- ***The control system is that means by which any quantity of interest in a machine, mechanism or other equipment is maintained or altered in accordance with a desired manner.***



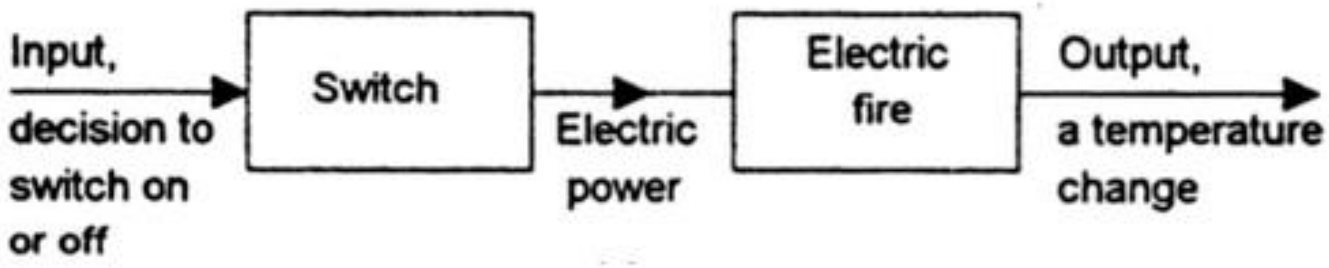
Your body temperature remains almost constant regardless of whether you are in a cold or hot environment. To maintain this constancy your body has a temperature control system. If your temperature begins to increase above the normal you sweat, if it decreases you shiver. Both these are mechanisms which are used to restore the body temperature back to its normal value. The control system is maintaining constancy of body temperature.

OPEN AND CLOSED LOOP CONTROL SYSTEMS

- There are two basic forms of control system, one being called ***open loop and the other closed loop***.

- Consider an electric fire which has a selection switch which allows a 1 kW or a 2kW element to heat a room, he or she might just switch on the 1 kW element if the room is not required to be at too high a temperature.

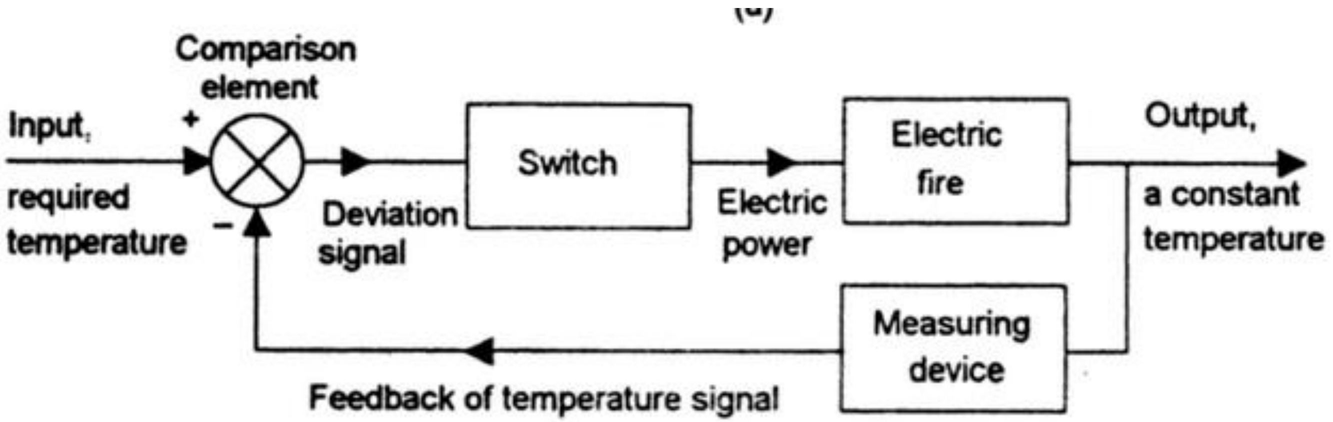
- The room will heat up and reach a temperature which is only determined by the fact the 1 kW element was switched on and not the 2 kW element. If there are changes in conditions, perhaps someone opening a window, there is no way the heat output is adjusted to compensate. This is an example of open loop control in that there is no information fed back to the element to adjust it and maintain constant temperature.



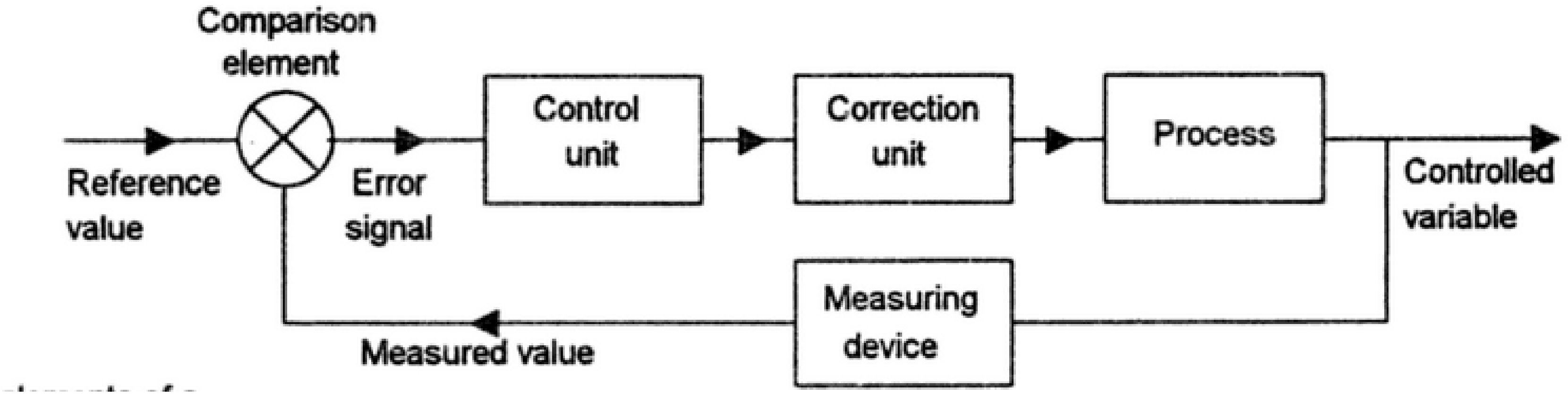
OPEN AND CLOSED LOOP CONTROL SYSTEMS

- The heating system with the heating element could be made a closed loop system if the person has a thermometer and switches the 1 kW and 2kW elements on or off, according to the difference between the actual temperature and the required temperature, to maintain the temperature of the room constant.

- In this situation, there is feedback, the input to the system being adjusted according to whether its output is the required temperature. This means that the input to the switch depends on the deviation of the actual temperature from the required temperature., the difference between them determined by a comparison element – the person in this case.



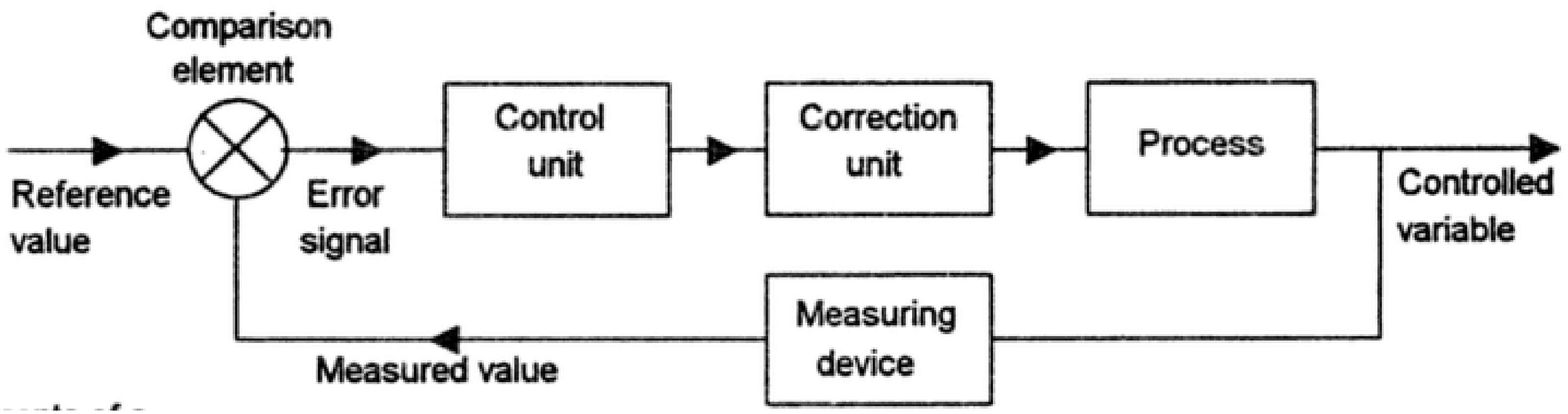
BASIC ELEMENTS OF A CONTROL SYSTEM



- ***Comparison element –*** This compares the required or reference value of the variable condition being controlled with the measured value of what is being achieved and produces an error signal.

Error signal = reference value signal – measured value signal

BASIC ELEMENTS OF A CONTROL SYSTEM

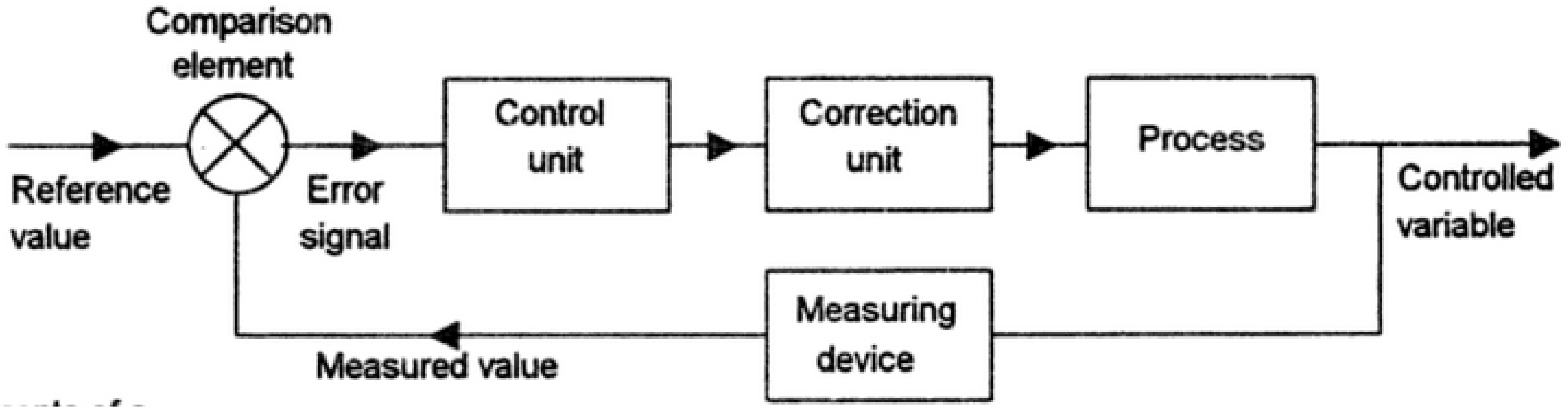


- ***Feedback loop –*** A feed back loop is a means whereby a signal related to the actual condition being achieved is fed back to modify the input signal to a process.

- ***Control unit –*** This decides what action to take when it receives an error signal.

- ***Correction unit –*** The correction unit produces a change in the process to correct or change the controlled condition.

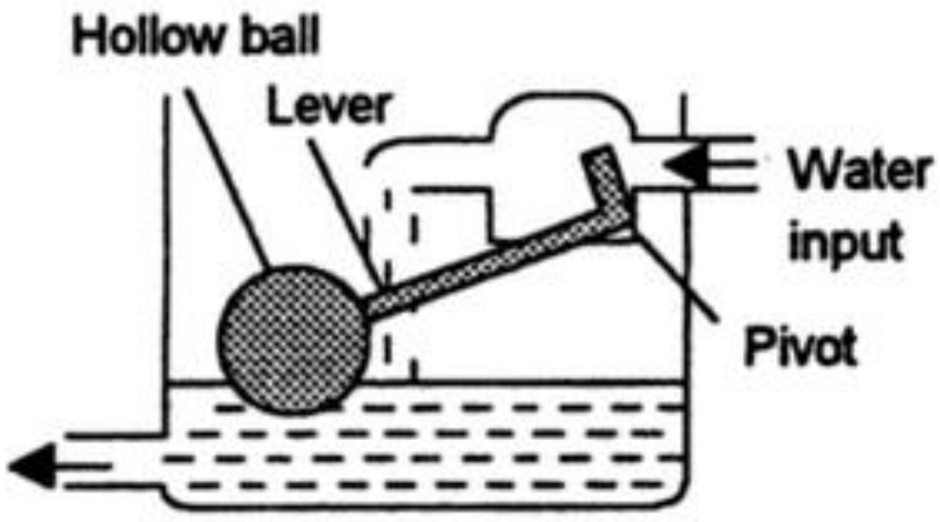
BASIC ELEMENTS OF A CONTROL SYSTEM



- ***Process unit –*** The process which is being controlled.

- ***Measurement unit –*** The measurement element produces a signal related to the variable condition of the process that is being controlled.

BASIC ELEMENTS OF A CONTROL SYSTEM



AUTOMATIC WATER LEVEL CONTROL

Identify controlled variable, reference value, comparison element, error signal, control unit, Correction unit, process and measuring unit????

MECHANICAL ENGINEERING SCIENCE (UE23ME131A)

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Unit4

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Chapter 2 – Automation, Robotics, Control Systems and Industry 4.0

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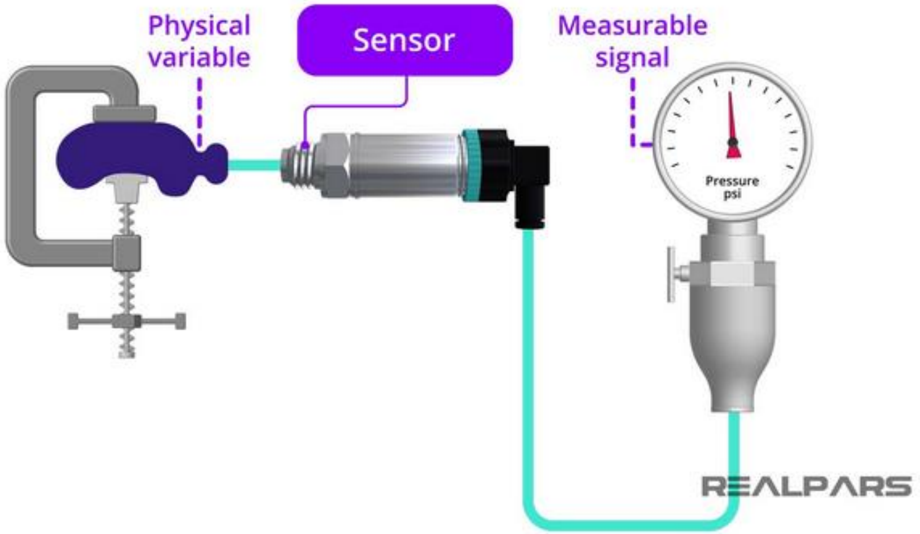
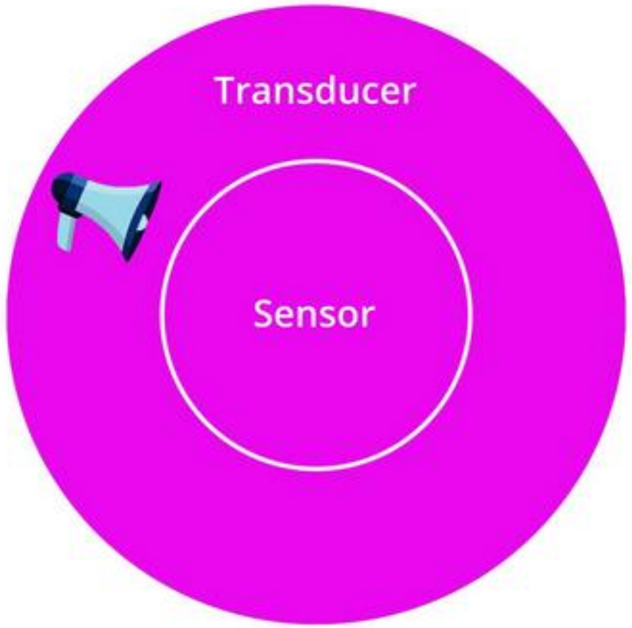
SENSORS AND TRANSDUCERS

- The term ***sensor*** is used for an element which produces a signal relating to the quantity being measured.

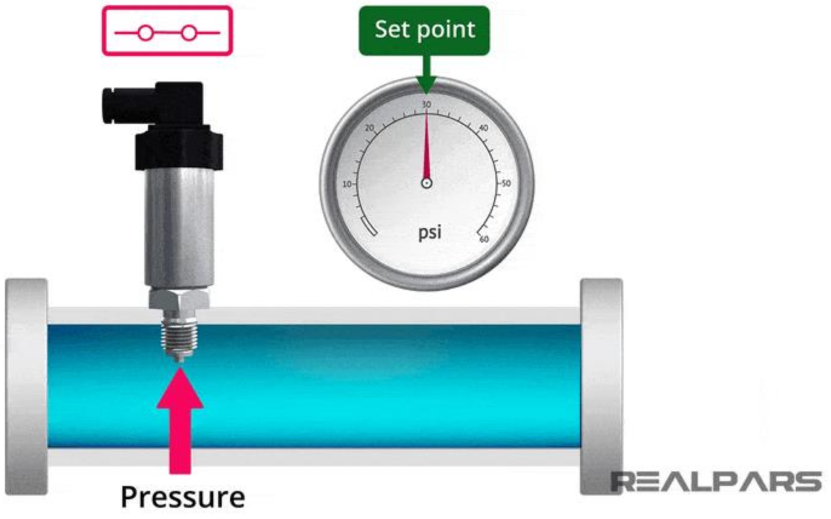
- The term ***transducer*** is defined as an element that when subject to some physical change experience a related change.

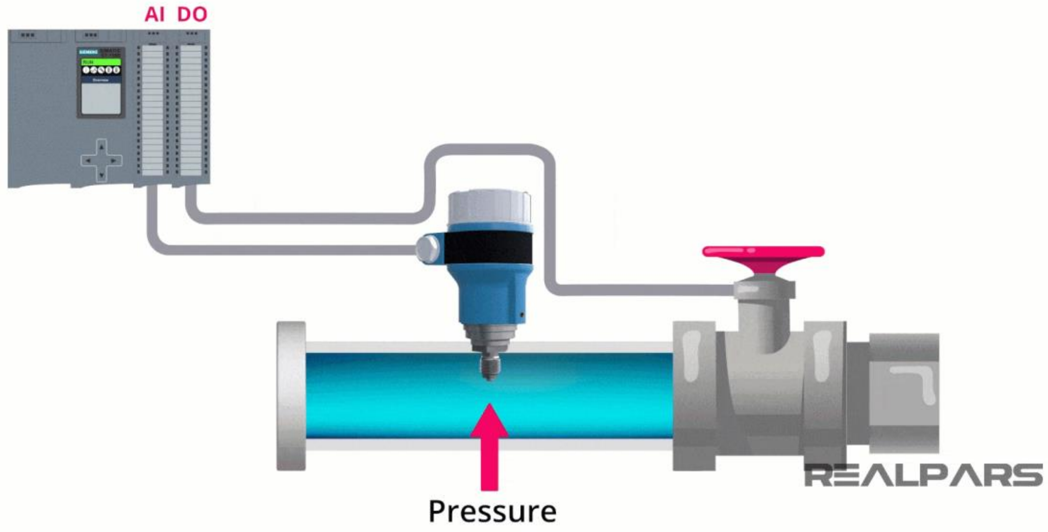




All sensors are transducers, but not all transducers are sensors.

SENSORS AND TRANSDUCERS



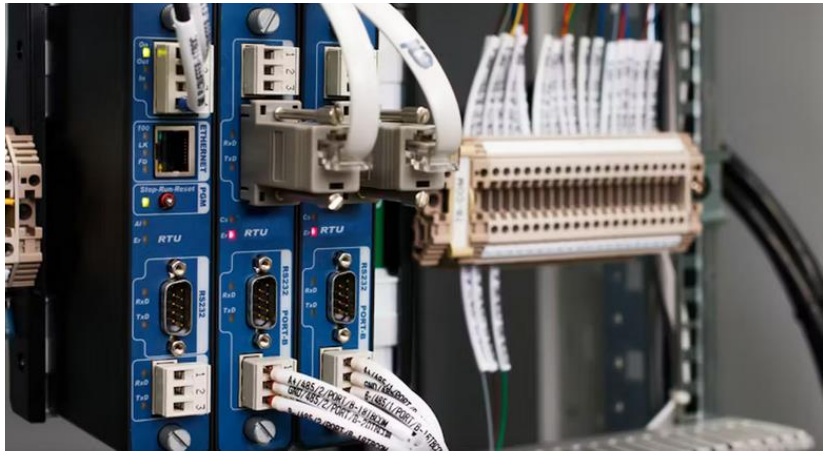


MICROPROCESSOR BASED CONTROLLERS

- Microprocessors are used in general to carry out control functions.

- In many simple systems there might be just an embedded microcontroller, this being a microprocessor with memory all integrated on one chip, which has been specifically programmed for the task concerned.

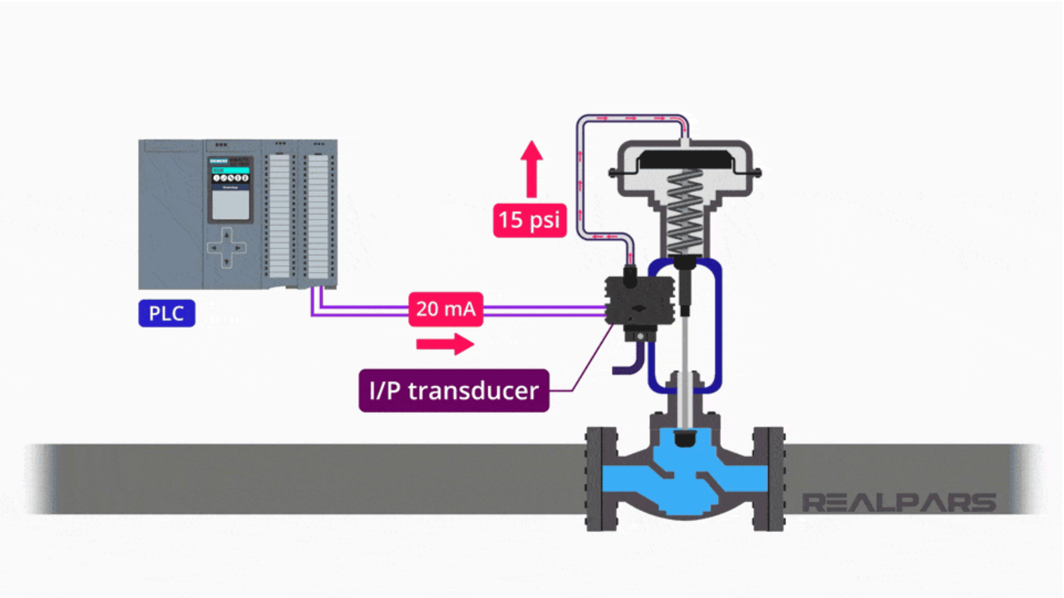
- A more adaptable form is the programmable logic controller. This is a microprocessor based controller which uses programmable memory to store instructions and to implement functions such as logic, sequence, timing counting, and arithmetic to control events and can be readily programmed for different tasks.



ACTUATION SYSTEMS

- ***Actuation systems are elements of control systems which are responsible for transforming the output of a microprocessor or control system into a controlling action on a machine or device.***

- Examples – an electrical output from the controller may have to be transformed into a linear motion to move a load, an electrical output from the controller may have to be transformed into a action which controls the amount of liquid passing along a pipe etc.



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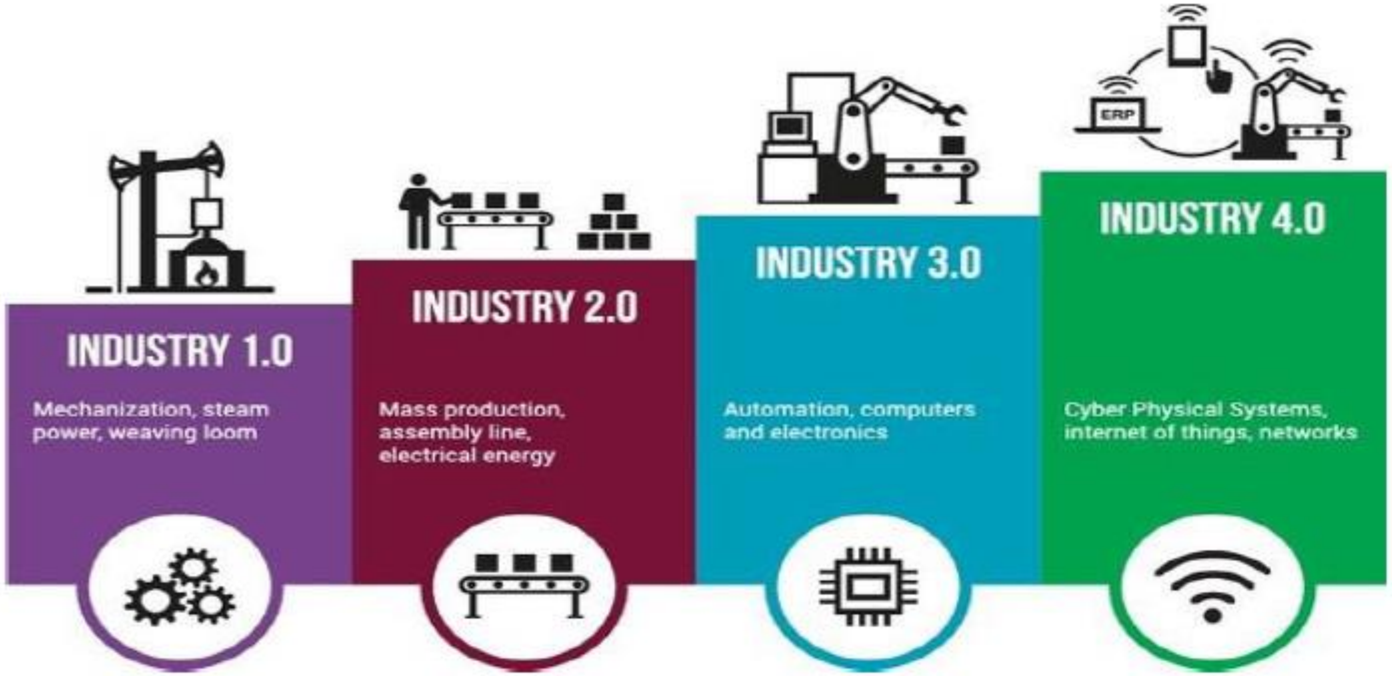
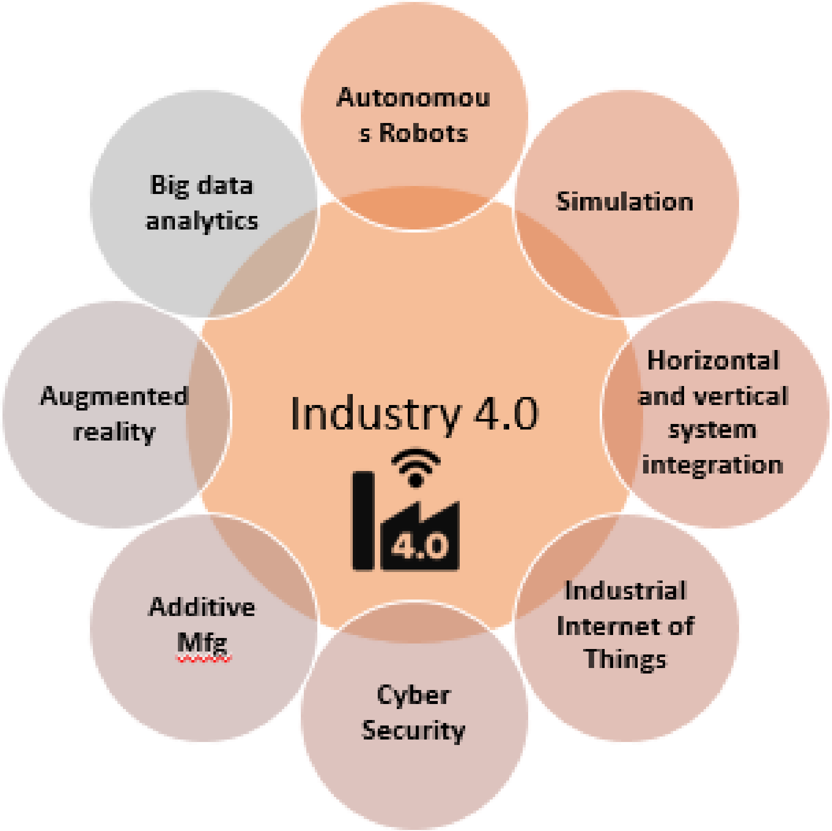
- *Industry 4.0 has been defined as **"a name for the current trend of automation and data exchange in manufacturing technologies, including cyber-physical systems, the Internet of things, cloud computing and cognitive computing and creating the smart factory".***



BUILDING BLOCKS OF INDUSTRY 4.0

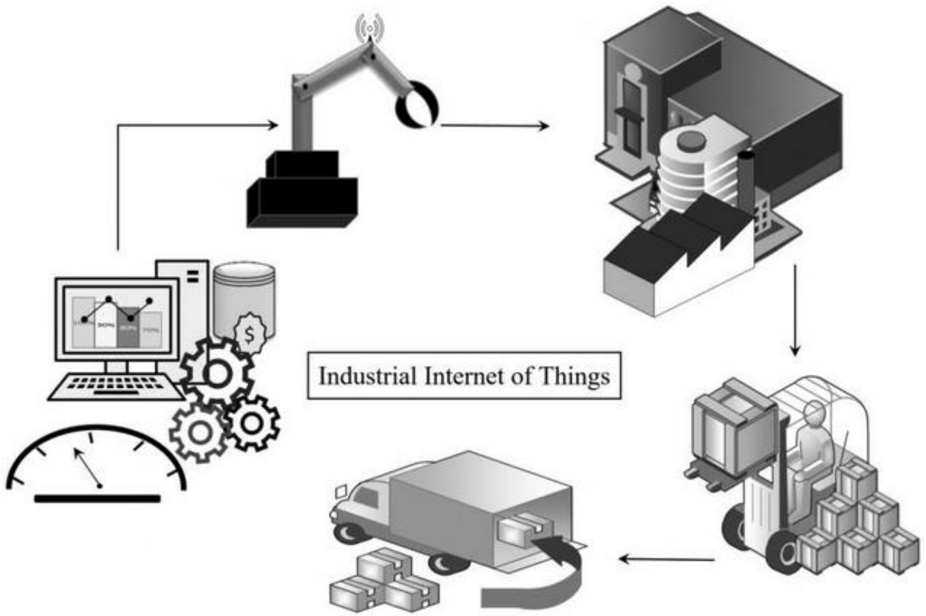


Industrial Internet of Things (IIoT)

- IIoT can be described as an interconnection of a large number of industrial processes and systems, which communicate and coordinate among themselves.

- The real time data collected from sensor nodes are stored, processed, and analysed to improve the performance and efficiency of the overall system.

- As shown in the figure, the sensor nodes deployed at various industrial locations sense and transmit data to the server. The real time processing and complex analysis of the data help to optimize various industrial processes such as **predictive maintenance of machines, inventory management and packaging of finished products.**

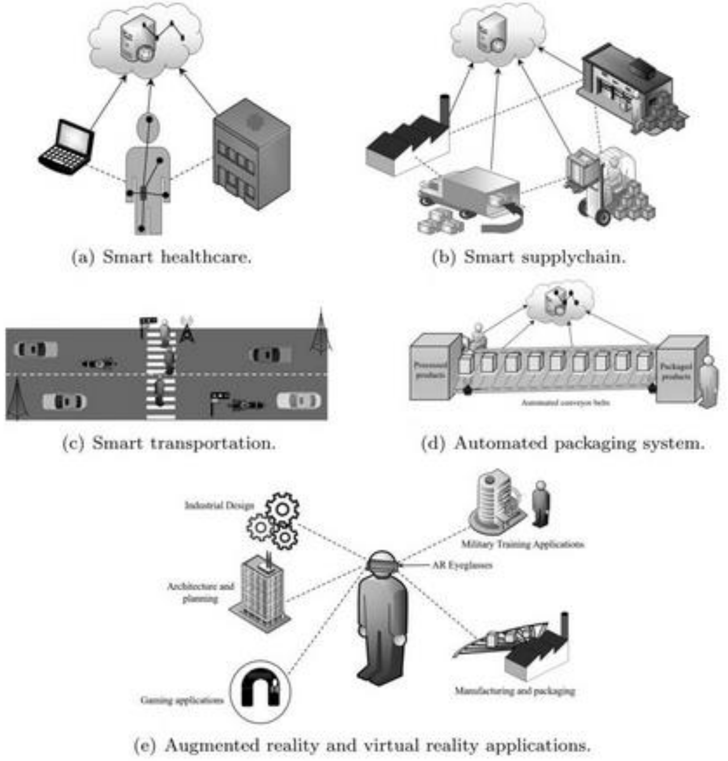


Applications of Industrial Internet of Things (IIoT)

1) ***Smart healthcare*** – Sensor nodes sense and transmit the physiological data of the patient to the local processing unit. Further, the LPU transmits the data to the local server. Medical experts can remotely observe the health conditions of the patient.

2) ***Smart supply chain*** - Proper maintenance of the raw materials, available inventory stock, details of each steps involved in the production process, proper flow of information among various stages , maintaining the time window for delivery of goods, and returning the faulty goods.

3) ***Smart transportation*** – The sensor nodes placed on the vehicles and road side units (RSU) sense and transmit data to the local server. Various real time info such as safe speed, safe distance with the neighboring vehicles, and weather conditions are conveyed to the drivers. (ITS and ADAS)



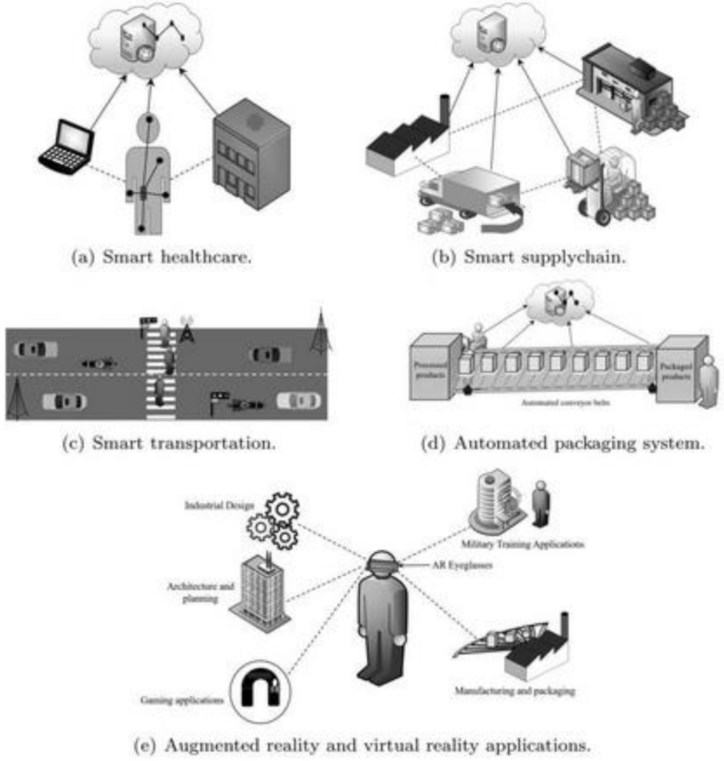
(a) Smart healthcare.
(b) Smart supplychain.
(c) Smart transportation.
(d) Automated packaging system.
(e) Augmented reality and virtual reality applications.

Applications of Industrial Internet of Things (IIoT)

4) Smart manufacturing system – These improve the efficiency of production and product quality, reduce the per unit cost of production and enhance the life time of machines and developed products.

e.g., Automatic packaging of a production in a manufacturing plant with minimum human intervention.

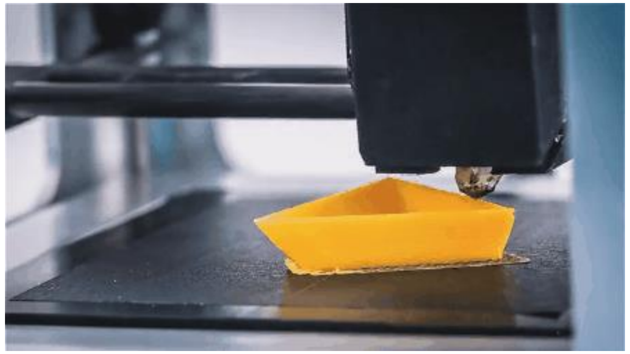
5) AR and VR applications **–** Augmented reality and virtual reality have widespread applications in the optimization satges of manufacturing industries, inventory management in warehouses, training of personnel in military, healthcare, and assembly line operations.



(a) Smart healthcare. (b) Smart supplychain. (c) Smart transportation. (d) Automated packaging system. (e) Augmented reality and virtual reality applications.

Additive manufacturing

- ***'Additive manufacturing fabricates parts by building them up layer-by-layer, as opposed to cutting material away or molding it'.***



- Additive manufacturing can also be viewed as a way to turn a digital model (of the object to be constructed) into a physical one since it starts as a (3D) software design.

- Additive manufacturing doesn't replace other manufacturing methods (at least not for many years to come) but leads to a wealth of new opportunities. Moreover, some objects would be almost impossible to make without additive manufacturing.

- ***Additive manufacturing and 3D printing are used in multiple domains (healthcare, the construction industry, defense, retail, pharma, automotive industry, aerospace, making parts in close to any area you can imagine, including human tissue and food, smart manufacturing). They are also the subject of intensive research and development (methods, materials, new techniques, application areas, etc.).***