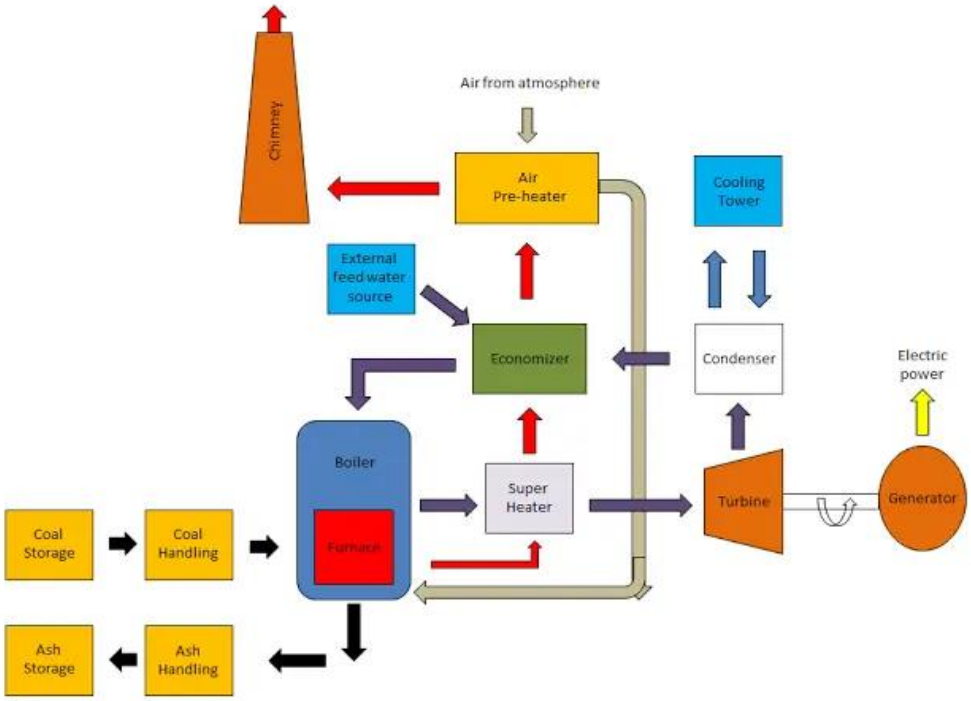
UNIT-III

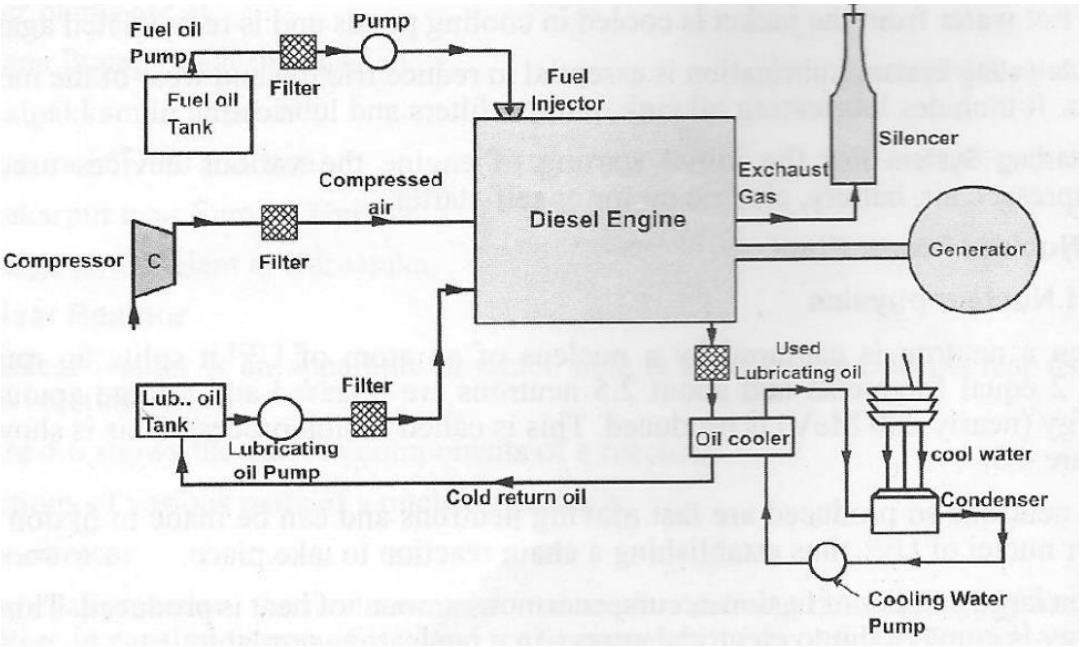
POWER PLANTS

Steam Power Plant:

1. The pulverised coal is fed into the boiler where the pulverised coal is burnt into the furnace
2. Due to heat from the furnace, the water present in the boiler drum changes to the high pressure steam.
3. From the boiler this high pressure steam is passed to the super heater where it is again heated up to its dryness.
4. After that this super-heated steam strikes the turbine blades with a high speed and the turbine blades starts rotating to at high speed. Here the stored potential energy of the steam is gets converted into mechanical energy.
5. A generator is coupled with the turbine rotor. As the turbine rotates, the generator also rotate with same speed and mechanical energy of the turbine gets converted into electrical energy.
6. Steam after hitting the turbines blades lost its most of the energy and leaves the turbine with low pressure steam.
7. This low pressure steam enters into the condenser. Cold water circulates in the condenser from the cooling tower. Here the low pressure wet steam is converted into water.
8. After that condensed water with the feed water passed to the economiser where it gets heated up by the economiser. And finally the feed water enters into the boiler by a feed water pump to repeat the cycle.
9. The burnt flue gases from the furnace passes through the super heater, economiser and air pre-heater. This heat of the flue gases is used to heat the steam in the super heater to its dryness, to heat feed water in the economiser before entering into the boiler and to heat air form the atmosphere in the air pre-heater before it enters into the furnace.
10. The ash from the furnace is transported to ash handling plant and finally to the ash storage



Diesel Power Plant:



Essential components of Disel engine :

ENGINE: This is the main component of the plant which develops required power. The engine is generally directly coupled to the generator • Generally classified as two stroke engine and four stroke engines.

Starting system : The function of this system is to start the engine from cold by supplying compressed air at about 17 bar supplied from an air tank. Fuel is admitted to the remaining cylinders and ignited in the normal way causing the engine to start.

Lubrication system:

• It includes the oil pumps, oil tanks, filters, coolers and connecting pipes.

• The purpose of the lubrication system is to reduce the wear of the engine moving parts

• Part of the cylinder such as piston , shafts , valves must be lubricated.

• Lubrication also helps to cool the engine.

Fuel system:

• It includes the storage tank, fuel pump, fuel transfer pump, strainers and heater.

• Pump draws diesel from storage tank to day tank through the filter

• Diesel is filtered before being injected into the engine by the fuel injection pump.

Cooling system:

The temperature of the hot gases inside the cylinder may be as high as 275^0 c .

If there is no external cooling, the cylinder walls and piston will tend to assume the average temp. of the gases.

• Cooling is necessary because

• To avoid deterioration or burning of lubricating oil.

• The strength of the materials used for various engine parts decreases with increase in temperature. Local thermal stress can develop due to uneven expansion of various parts.

• Due to high cylinder head temp. the efficiency and hence power O/P of the engine are reduced.

Exhaust system

• This includes the silencers and connecting ducts.

• The exhaust gases coming out of the engine is very noisy.

• silencer (muffler) is provided to reduce the noise.

NUCLEAR POWER PLANT

Main components

It was previously indicated that a nuclear reactor is a site that can initiate, sustain and stop nuclear fission chain reactions in a controlled way, with the adequate means to extract the generated heat.

Pressurizer:
A component of the primary coolant circuit. It balances the liquid stage and the steam stage at conditions of saturation in order to control its pressure.

Reactor vessel:
A steel vessel that houses the nuclear reactor, the main component of the nuclear power plant, where the chain reaction nuclear fission takes place. The nucleus is composed of the fuel elements.

Fuel. The material, usually enriched uranium dioxide, where the fission reactions take place. It is used simultaneously as a source of energy and of neutrons to sustain the chain reaction. It is presented in a solid state in the form of cylindrical pills encapsulated into metallic rods a few meters long.

- **Shielding**. It prevents the leak of radiations and neutrons from inside the reactor to the outside. Usually shielding is made up of concrete, steel or lead.

- **Moderator**. Water that slows down the fast neutrons generated by the fission, which leads to new fissions and the sustainment of the chain reaction.

- **Control rods**. The control elements in the reactor. They act as neutron absorbers. These rods are made of indium-cadmium or boron carbide and make it possible to constantly control the neutron population whilst keeping the reactor stable; they also make it possible to stop the reaction whenever necessary.

- **Cooling water**. The main use of cooling water in a nuclear reactor is to remove excess heat generated during the nuclear fission process.

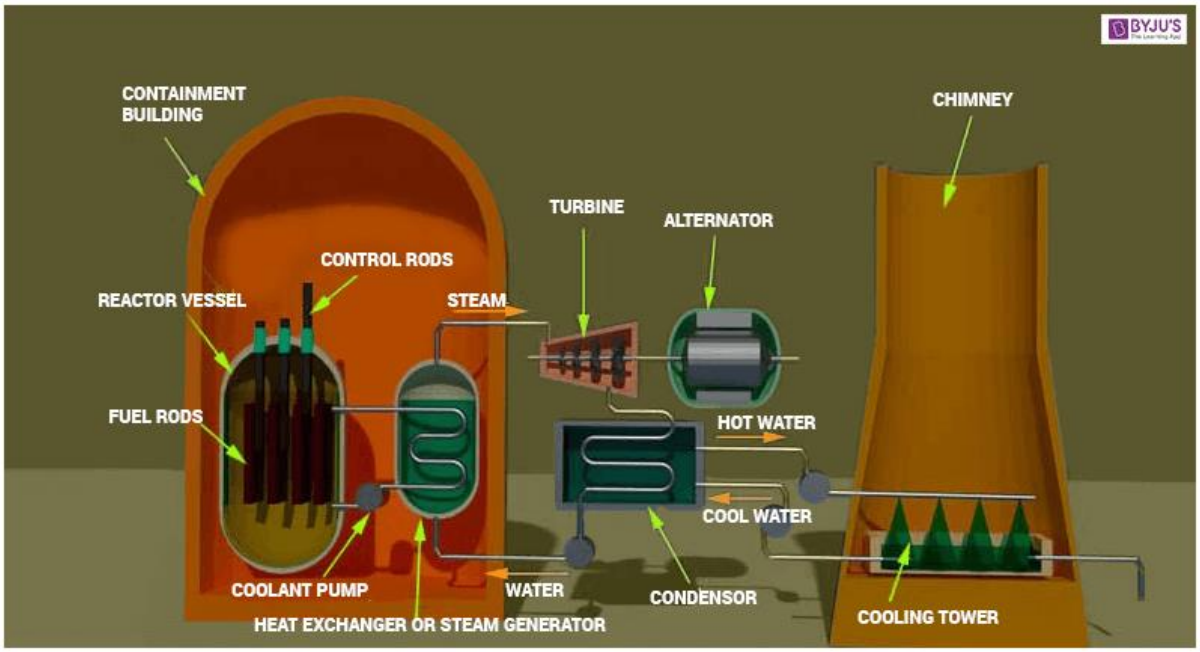
- **Steam generator:** Heat exchangers where the primary circuit coolant water, which circulates inside the inverted U-shaped tubes, gives all its energy to the secondary circuit and becomes water steam.

- **Turbine**: This is where the water steam from the steam generators is collected, and where the vanes transform its energy into mechanical rotation energy. There are various sections for the expansion of steam. The axis is firmly attached to the alternator axis.

- **Alternator:** A system that produces electricity by converting the turbine's mechanical rotation energy into medium-power, high-intensity electric energy.

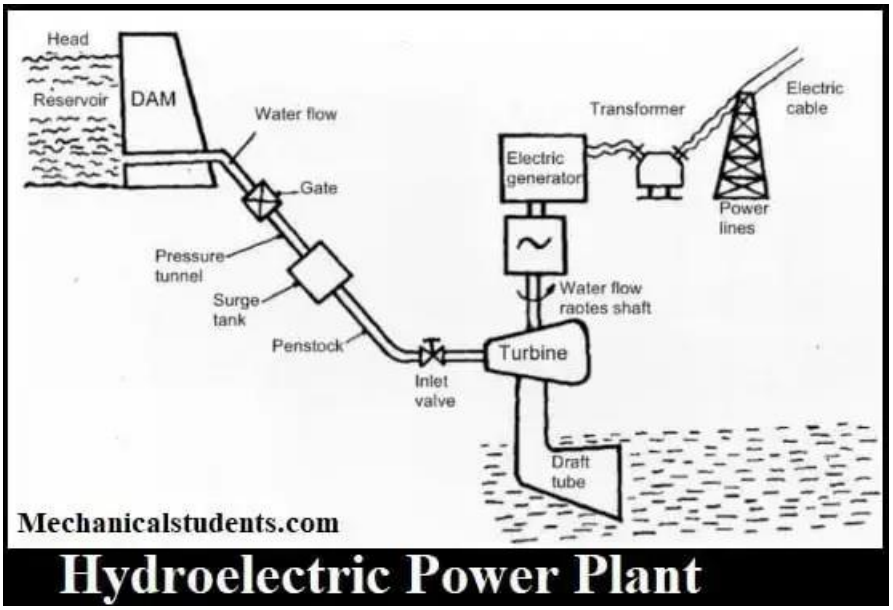
- **Cooling tower:**

  A site that makes it possible to send out to the atmosphere part of the residual heat produced in the generation of electricity; the atmosphere acts as a cold focus. It is used to cool down the water that circulates through the condenser and is part of the plant's auxiliary cooling circuit.



11. Hydro Power Plant:

- Reservoir and Dam
- Control Gate
- Penstock
- Surge Tank
- Water Turbine
- Generator



Reservoir and Dam:

The dam is constructed on a large river to ensure sufficient water storage and the dam forms a large reservoir behind it. The height of the water level (called a water head) in the reservoir determines the potential energy stored in it.

Control Gate:

The amount of water released in the penstock can be controlled by a control gate

Penstock:

A penstock is a steel pipe which carries water from the reservoir to the turbine. The potential energy of the water is converted into kinetic energy as it flows down through the penstock due to gravity.

Water Turbine:

Water from the penstock is to be traveled to the water turbine and the turbine is coupled to an electric generator. Kinetic energy (K.E.) of the water drives the turbine and consequently, the generator gets driven.

Generator:

A generator is placed or mounted in the powerhouse which is coupled to the shaft of the turbine. The passage of water from the nozzle hits the turbine blades which makes the shaft of the turbine to rotate. It drives the generator and electricity are produced.

The produced electricity will be Step up or Stepdown through a transformer and later on it will supply to the domestic and industrial applications.

The water passing through the turbine is discharged to the tailrace which carries water away from the powerhouse after it has been passed through the turbine.

Working of Hydroelectric Power Plant is as follows:

The dam is constructed on a large river to ensure sufficient water storage and the dam forms a reservoir behind it. The height of the water level (called a water head) in the reservoir determines the potential energy stored in it. The water is travelled from the reservoir passing through the gates. Water initially with some potential energy is converted to high-pressure energy during the passage.

A surge tank is placed at the top and is fitted between the reservoir and the powerhouse. This water level rises or falls to reduce the pressure in the penstock. The maximum amount of water is released through the penstock when the control gate is fully opened. This kinetic energy is converted to electrical energy, as the turbine is coupled to an electric generator.

The passage of water from the nozzle hits the turbine blades which makes the shaft of the turbine to rotate. It drives the generator and electricity are produced. The water which moves away from the turbine enters into the Afterbay via Tailrace.

Mechanical Power Transmission

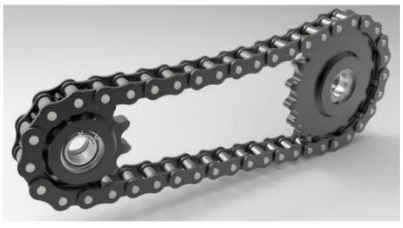
Mechanical power transmission is the process of transferring energy from one location to another, allowing work to be performed. This energy is typically in the form of rotational motion or torque. Different mechanical systems and components are used to transmit power effectively and efficiently, depending on the application.

Key components of mechanical power transmission include:

1. **Belt Drives**
   Belt drives use flexible belts and pulleys to transmit power between shafts. They are commonly used where flexibility, simplicity, and cost-efficiency are needed.
2. **Chain Drives**
   Chain drives use a series of interlinked chains and sprockets to transmit power. These are preferred in applications where more positive engagement and higher power transmission are required.
3. **Rope Drives**
   Rope drives use ropes, typically made of natural or synthetic fibers, wrapped around pulleys to transmit power. These drives are used for long-distance power transmission and when flexibility is important.
4. **Gear Drives**
   Gear drives use meshing gears to transmit power between shafts. They are known for their precision and ability to handle high-torque applications.

Types

- Belt Drive
- Chain Drive
- Rope Drive
- Gear Drive



Belt Drives

Belt drives are one of the simplest and most widely used methods for mechanical power transmission in machinery. They are used to transmit power between two rotating shafts, typically in applications like motors, fans, conveyors, and more.

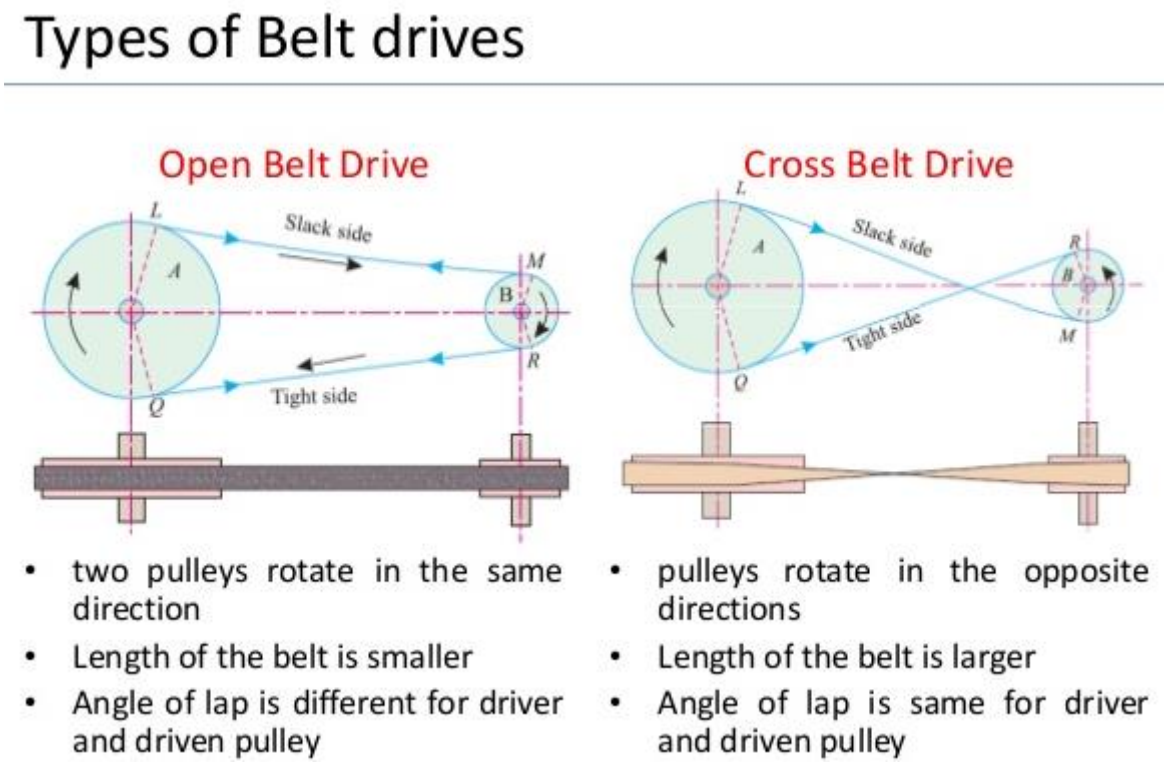
Belt drives are mechanical devices that transmit power between rotating shafts using belts. They are classified based on various criteria, including the configuration of the belt, the orientation of the drive, and the type of materials used. Here's a breakdown of the classification of belt drives:

1. Based on the Configuration of the Belt

- **Flat Belts**: These are flat strips of material, typically made of rubber or leather, used for transmitting power between shafts that are parallel to each other. They are widely used in low-power applications.
- **V-Belts**: Shaped like a "V," these belts fit into grooves on the pulleys, providing better grip and minimizing slippage. They are commonly used in automotive and industrial applications.
- **Round Belts**: These are circular in cross-section and are often used in light-duty applications where flexibility and small pulley sizes are required.
- **Timing Belts**: These have teeth that fit into corresponding grooves on the pulleys, ensuring a precise movement between the two shafts. They are commonly used in applications requiring synchronization.

2. Based on the Orientation of the Drive

- **Open Belt Drive**: In this configuration, the two pulleys are arranged parallel to each other, and the belt runs in a single loop from one pulley to the other. This arrangement is commonly used for simple power transmission.
- **Cross Belt Drive**: The belt crosses over itself when connecting the two pulleys, allowing for a different direction of rotation. This is used when pulleys are positioned at different heights.



Components of Belt Drive

1. **Driver Pulley (Driving Pulley)**:
    - The pulley connected to the power source (like an engine or motor).
    - This pulley transmits power to the belt.
2. **Driven Pulley (Follower Pulley)**:
    - The pulley that receives power from the belt to drive a machine.
3. **Belt**:
    - A flexible element made of rubber, leather, fabric, or other materials that wraps around the pulleys to transmit power.

Important Terms in Belt Drives

1. **Tight Side and Slack Side**:
    - In a belt drive, the tension is not uniform throughout the belt.
    - The **Tight Side** is the part of the belt under higher tension as it comes from the driver pulley.
    - The **Slack Side** is the part of the belt under lower tension as it moves towards the driver pulley after passing the driven pulley.
2. **Slip**:
    - Slip occurs when the belt does not move at the same speed as the pulley it is supposed to drive. This happens due to insufficient friction between the belt and the pulley.
    - **Slip percentage** is defined as the difference in speed between the driver and the driven pulley.

$$[\{\text{Slip Percentage}\} = (\frac{N_1 - N_2}{N_1}) \times 100]$$

Where:

- N_1 = Speed of the driver pulley (in RPM)
- N_2 = Speed of the driven pulley (in RPM)

This formula calculates the percentage of slip in a belt drive by comparing the difference in speed between the driver and driven pulleys relative to the speed of the driver pulley.

3. **Creep**:
    - Creep is the result of the difference in the length of the belt on the tight side and slack side.
    - The belt tends to stretch more on the tight side due to higher tension, leading to a slight difference in velocity between the tight side and slack side. This also results in a slight reduction in the effective speed of the driven pulley.

Advantages of Belt Drives

- **Simple design**: Easy to install and operate.
- **Flexible**: Can be used for transmitting power over a large distance.
- **Cost-effective**: Low maintenance and cheaper compared to other transmission systems.
- **Shock absorption**: The belt can absorb shocks and vibrations, protecting both the driver and driven machinery.

Disadvantages of Belt Drives

- **Slip and Creep**: These reduce the efficiency of power transmission.

- **Limited torque**: Not suitable for applications where very high torque is required.
- **Wear and tear**: Belts need frequent inspection and replacement due to wear, stretching, or cracking.

Applications of Belt Drives

- Automotive systems (fan belts, alternators)
- Industrial machines (conveyors, compressors)
- Agricultural machinery (pumps, mills)
- Home appliances (washing machines, vacuum cleaners)

Chains

Introduction to Chains:

Chains are mechanical devices used to transmit power between two rotating shafts or components. They are commonly used in various industries, including automotive, agriculture, and manufacturing, due to their reliability and strength. Chains function by meshing with sprockets, which have teeth that engage with the links of the chain, allowing power transmission without slip.

Chain Drives:

1. **Chain drives mainly classified to**

    a) Load lifting b) Hauling chains c) Power transmission chains

a) Load lifting chains :
Load lifting/crane 'hoisting chains are used for suspending, raising or lowering loads in material handling equipment. Eg: link chain, leaf chain

b) **Hauling chains/conveyor or tractive chains** are used for carrying materials continuously by sliding, pulling or carrying in conveyors. Eg: Block chain, laminated metal chain

c) **Power transmission chains** are used for transmitting power from one shaft to another. Eg: Roller chain-duplex chain, silent chain

Types of Chains:

Power-transmitting chains are used when the distance between the centers of shafts is short, and they typically include provisions for efficient lubrication. These chains are commonly categorized into the following types:

1. **Block or Bush Chain:**
   Block or bush chains were used in the early stages of power transmission development. A block chain consists of solid blocks connected by side plates and is shown in Figure 2. These chains tend to produce noise when approaching or leaving the teeth of the sprocket due to rubbing between the links and the sprocket teeth.

Although outdated for modern power transmission, block chains are still used to some extent in conveyor systems operating at low speeds.

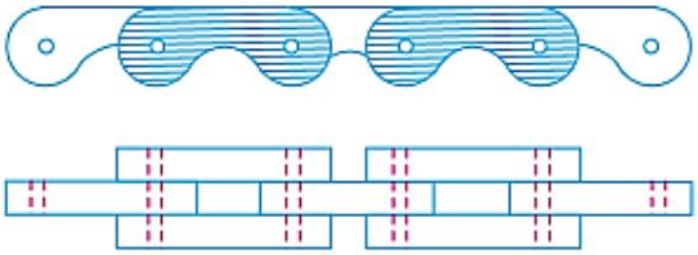
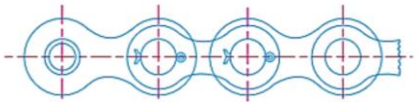


Figure 2: Block or bush chain.

2. **Bush Roller Chain:**
   The bush roller chain, illustrated in Figure 3, is composed of outer plates (pin link plates), inner plates (roller link plates), pins, bushes, and rollers. The pins pass through the bushes, which are secured in the roller link plates. The rollers rotate freely on the bushes, preventing excessive wear on the sprocket teeth. Bush roller chains are commonly made of alloy steel and are widely used due to their durability and efficiency in protecting sprocket teeth against wear.



3. **Silent Chain (Inverted Tooth Chain):**
   Silent chains, as shown in Figure 5, are designed to reduce noise and eliminate the issues caused by chain stretching. When the chain stretches, the pitch increases, and the links ride on the sprocket teeth at a slightly larger radius, automatically correcting the pitch change. This results in a smooth and quiet operation with no relative sliding between the chain links and the sprocket teeth. Silent chains are commonly used in applications where low noise and smooth operation are essential, such as automotive timing systems.

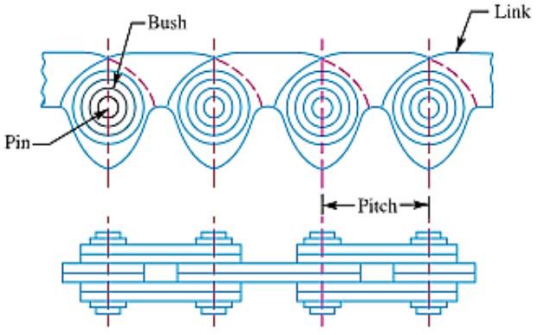


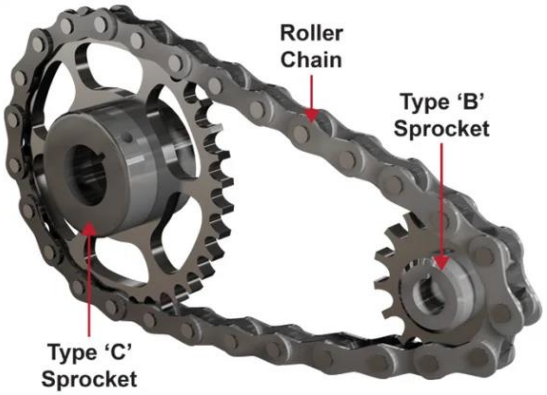
Figure 5: Silent chain.

In addition to these three types, several other types of chains are used for specialized applications:

4. **Roller Chains:**
   The most common type of chain, consisting of inner and outer links, rollers, and pins. These chains are extensively used in bicycles, motorcycles, and conveyors due to their versatility and efficiency.
5. **Leaf Chains:**
   These chains are specialized for lifting applications rather than power transmission, commonly found in equipment such as forklifts and cranes.
6. **Timing Chains:**
   Timing chains are used to ensure synchronization between different moving components, most notably in internal combustion engines to control valve timing.
7. **Conveyor Chains:**
   Designed specifically for material handling, conveyor chains are used to move products along conveyor systems in various industries.

Chain Drive Components:

1. **Chain**: The flexible link mechanism that transmits power.
2. **Sprockets**: Toothed wheels that engage with the chain to drive or be driven.
3. **Tight Side**: The side of the chain under tension due to power transmission.
4. **Slack Side**: The side of the chain with less tension, where the chain tends to sag.



Working Principle:

Chain drives operate by engaging a chain with sprockets mounted on shafts. As the driving sprocket rotates, it pulls the chain, transferring rotational motion to the driven sprocket. The power transmission is achieved **without slip**, ensuring efficiency and consistent speed ratios between the driving and driven sprockets.

Advantages of Chain Drives:

1. **No Slip:** Chain drives do not experience slippage, ensuring accurate and reliable power transmission.
2. **High Efficiency:** Chains offer high mechanical efficiency, especially under high-load conditions, with transmission efficiencies of up to 98%.
3. **Durability:** Chains are robust and can handle harsh operating environments, making them suitable for heavy-duty applications.
4. **Compact Design:** Chains occupy less space in width compared to belt or rope drives for transmitting the same amount of power.
5. **Flexibility in Distance:** Chain drives can be used for both long and short distances.
6. **Reduced Load on Shafts:** Chain drives exert less load on the shafts.
7. **Power Transmission to Multiple Shafts:** A single chain can transmit motion to several shafts.
8. **High Power Transmission:** Chains transmit more power than belts.
9. **High-Speed Ratio:** Chain drives allow a high-speed ratio of 8 to 10 in a single step.
10. **Operation in Adverse Conditions:** Chains can operate effectively under adverse temperature and atmospheric conditions.

Disadvantages of Chain Drives:

1. **Maintenance:** Chains require regular lubrication and tension adjustment to prevent wear and ensure proper functioning.
2. **Noise:** Roller and leaf chains can produce noise, especially at high speeds or under heavy loads.
3. **Limited Flexibility:** Unlike belt drives, chain drives lack flexibility and require precise alignment of sprockets.
4. **Production Cost:** Chains have a relatively high production cost.
5. **Velocity Fluctuations:** Chain drives may experience velocity fluctuations, particularly when unduly stretched.
6. **Accurate Mounting Needed:** Chain drives require accurate mounting and careful maintenance to ensure smooth operation.

Key Concepts in Chain Drives

Tight Side:

- The **tight side** is the side of the chain under higher tension due to the driving force. It is responsible for transmitting the power and is typically located on the lower side of the chain drive (when the driver is below the driven sprocket).

Slack Side:

- The **slack side** is the side of the chain that has less tension and typically sags. It is located on the opposite side of the tight side, and it is essential to maintain proper chain tension to prevent excessive slack that could lead to chain jumping or wear.

Chain Slip:

- **Slip** occurs when a power transmission device fails to transfer motion effectively. However, chain drives generally do not suffer from slip, unlike belt drives. Slip can be caused by wear or elongation in the chain or improper engagement with the sprockets, leading to decreased efficiency or failure.

Chain Elongation:

- Over time, chain links may elongate due to wear, resulting in increased slack. This elongation can affect power transmission, requiring periodic tension adjustments or chain replacement.

Applications of Chain Drives:

1. **Bicycles and Motorcycles**: Chains are commonly used to transmit power from the pedals to the wheels in bicycles and from the engine to the rear wheel in motorcycles.
2. **Conveyor Systems**: In industries, chains are used in conveyors to move materials efficiently.
3. **Automotive Timing Systems**: Timing chains ensure that the engine's valves open and close in sync with the pistons.
4. **Agriculture Equipment**: Chain drives are used in tractors, harvesters, and other agricultural machinery for power transmission.

Lubrication and Maintenance:

- **Lubrication**: Proper lubrication of chain drives is essential to reduce friction, wear, and noise. Lubricants should be applied regularly to ensure smooth operation.
- **Tension Adjustment**: Chain tension should be monitored and adjusted periodically to prevent excessive slack or tightness, which can lead to premature wear or failure.
- **Sprocket Inspection**: Sprockets should be inspected for wear, as worn teeth can reduce engagement with the chain and cause slip or failure.

Ropes

Rope drives are one type of mechanical power transmission system where ropes, typically made of natural fibers (e.g., hemp, cotton) or synthetic materials (e.g., nylon, polyester), are used to transmit power between pulleys. Rope drives are suitable for transmitting power over long distances, and they are often used in situations where large pulleys and long center distances are required, such as in cranes, elevators, and mines.

Types of Ropes in Power Transmission

1. **Fiber Ropes:**
    - **Materials:** Hemp, manila, cotton, or synthetic fibers.
    - **Advantages:** Flexible, light, and relatively inexpensive.
    - **Disadvantages:** Subject to wear and tear, lower strength compared to metal ropes.
2. **Wire Ropes:**
    - **Materials:** Steel wires braided together to form a strong and flexible rope.

- **Advantages:** High strength, durable, resistant to wear.
- **Disadvantages:** Heavier, costlier, requires lubrication to prevent corrosion.

Terminology in Rope Drives

1. **Tight Side:**
   - The tight side of the rope is the side that carries most of the load and is under tension. It occurs on the side where the pulling force is applied, causing the rope to be in a stretched condition. The tension in the tight side is greater compared to the slack side.
2. **Slack Side:**
   - The slack side is the opposite side of the tight side, and it is under relatively lower tension. The tension on the slack side is much less since this side is not carrying the primary load. The tension difference between the tight and slack sides helps in the transmission of power.
3. **Slip:**
   - Slip in a rope drive refers to the difference between the linear velocity of the pulley and the rope due to stretching or elasticity. When a rope drive operates, there might be slight slipping of the rope over the pulleys due to tension differences, leading to a reduction in power transmission efficiency. Slip is usually expressed as a percentage.
4. **Creep:**
   - Creep in rope drives refers to the gradual elongation or stretching of the rope under continuous load. This phenomenon is more noticeable in fiber ropes, which can permanently elongate over time, causing tension loss and reducing power transmission efficiency.

Applications of Rope Drives:

1. **Cranes and Hoists:**
   Rope drives are commonly used in cranes and hoists to lift heavy loads. They enable the transmission of power over long distances in vertical motion, making them essential for construction, industrial, and logistics applications.
2. **Elevators:**
   In elevators, wire ropes provide the necessary strength and durability to lift and lower elevator cars. Their ability to handle significant loads while offering flexibility makes them ideal for use in multi-story buildings.
3. **Mining:**
   Rope drives play a vital role in the mining industry, where they are used to transport materials over long distances. These ropes are used in conjunction with pulley systems, ensuring the efficient movement of ores and other materials through conveyor systems.
4. **Suspension Bridges:**
   Rope drives are also utilized in suspension bridges, where they help support the weight of the bridge deck. These ropes provide stability and distribute the load across the bridge structure, ensuring its durability and safety.

Advantages of Rope Drives

1. Can transmit power over long distances.

2. Flexible and lightweight (for fiber ropes).
3. Can accommodate large center distances.
4. Suitable for low-speed, high-torque applications.

Disadvantages of Rope Drives

1. Slip and creep reduce efficiency.
2. Fiber ropes have limited lifespan due to wear and tear.
3. Wire ropes require regular maintenance and lubrication to prevent corrosion.
4. Not suitable for very high-speed applications.

Gear Drives:

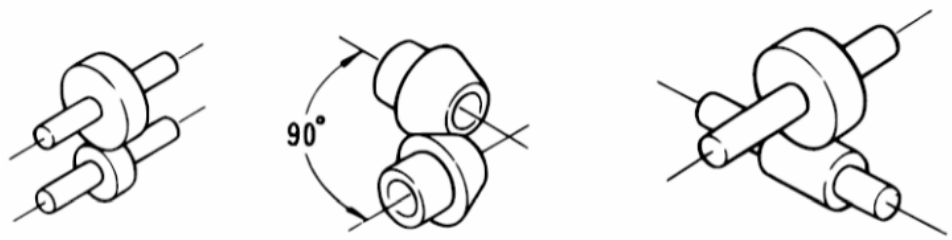
Gear drives rely on toothed gears to transmit motion and power. They are known for their precision, efficiency, and ability to transmit power at various speeds and torques. Gear drives find applications in a wide range of industries, from automotive to aerospace.

1. To increase or decrease the speed of rotation
2. To change the amount of force or torque
3. To change the rotation of motion
4. To reverse the direction of motion

According to the position of shaft axes:

Gears may be classified according to the relative position of the axes of revolution. The axes may be:

1. **Parallel** shafts where the angle between driving and driven shaft is 0 degree. Examples include spur gears, single and double helical gears.
2. **Intersecting** shafts where there is some angle between driving and driven shaft. Examples include bevel and miter gear.
3. **Non-intersecting and non-parallel** shafts where the shafts are not coplanar. Examples include the hypoid and worm gear.



Parallel Axis | Intersecting Axis | Non Parallel Non Intersecting Axis

According to type of gears:

Gears can be classified as external gears, internal gears, and rack and pinion.

1. **External gears** mesh externally - the bigger one is called "gear" and the smaller one is called "pinion".
2. **Internal gears** mesh internally - the larger one is called "annular" gear and the smaller one is called "pinion".
3. **Rack and pinion type –** converts rotary to linear motion or vice versa. There is a straight line gear called "rack" on which a small rotary gear called "pinion" moves.

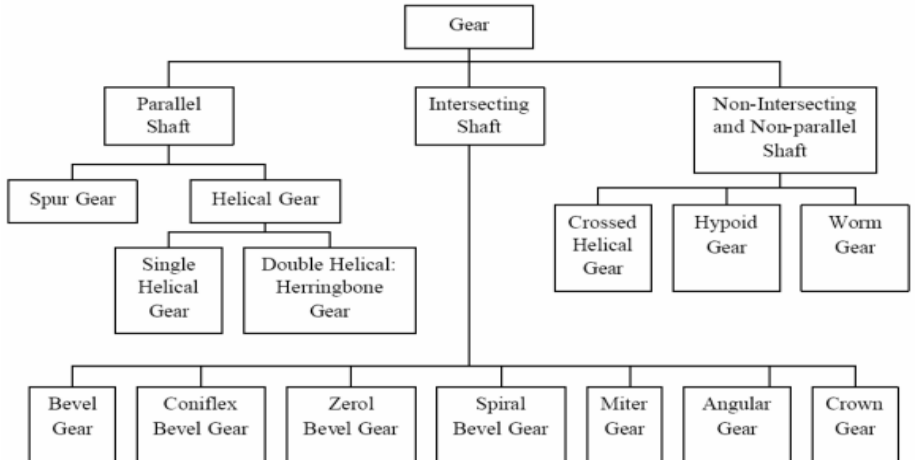
According to teeth position:

Gears are classified as straight, inclined and curved.

1. **Straight gear teeth** are those where the teeth axis is parallel to the shaft axis.
2. **Inclined gear teeth** are those where the teeth axis is at some angle.
3. **Curve gear teeth** are curved on the rim's surface.

TYPE OF GEARS

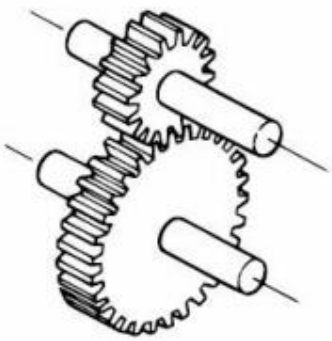
Here is a brief list of the common forms.



(Axis parallel: Spur gear)

SPUR GEARS

Spur gears are used to transmit power between two parallel shafts. The teeth on these gears are cut straight and are parallel to the shafts to which they are attached.



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(Axis Intersecting : bevel gear)

BEVEL GEARS

A bevel gear is shaped like a section of a cone and primarily used to transfer power between intersecting shafts at right angles. The teeth of a bevel gear may be straight or spiral. Straight gear is preferred for peripheral speeds up to 1000 feet per minute; above that they tend to be noisy.

8(Axis Non-Intersecting and Non parallel gear: worm Gear)

WORM GEARS

Worm gears are used to transmit power between two shafts that are at right angles to each other and are non-intersecting.

Worm gears are special gears that resemble screws, and can be used to drive spur gears or helical gears. Worm gearing is essentially a special form of helical gearing in which the teeth have line contact and the axes of the driving and driven shafts are usually at right angles and do not intersect.

Worm Gear

Applications

1. **Spur Gears**:

- **Industrial Machinery**: Spur gears are used in industrial machinery for speed reduction or speed increase applications.
- **Automotive Transmissions**: They are used in manual and automatic transmissions to transmit power from the engine to the wheels.
- **Watches and Clocks**: Spur gears are used in the gear trains of mechanical watches and clocks.

2. **Helical Gears**:
   - **Automotive Transmissions**: Helical gears are often used in automotive transmissions for a smoother and quieter operation.
   - **Machine Tools**: They are used in machine tools for power transmission.
   - **Agricultural Equipment**: Helical gears can be found in farm machinery and tractors.
3. **Bevel Gears**:
   - **Differential Mechanisms**: Bevel gears are commonly used in differential mechanisms in vehicles to allow the wheels to rotate at different speeds when turning.
   - **Marine Applications**: Bevel gears are used in marine propulsion systems.
   - **Aerospace**: Bevel gears can be found in aircraft landing gear systems.
4. **Worm Gears**:
   - **Lifts and Elevators**: Worm gears are used in lifts and elevators for their self-locking feature.
   - **Conveyor Systems**: They are used in conveyor systems for material handling.
   - **Gate and Valve Actuators**: Worm gears are used in gate and valve actuation systems of the generator.
5. **Hypoid Gears**:
   - **Automotive Rear Axles**: Hypoid gears are commonly used in rear axles of vehicles.
   - **Machine Tools**: They can be found in certain types of machine tools.
   - **Agricultural and Construction Equipment**: Hypoid gears are used in heavy machinery.
6. **Straight Bevel Gears**:
   - **Hand Tools**: Straight bevel gears can be found in hand-operated tools like hand drills.
   - **Marine Propulsion**: They are used in marine propulsion systems.

The choice of gear type depends on the specific application, design requirements, and desired performance characteristics such as torque, speed, efficiency, and noise levels. Gears play a crucial role in the functioning of various mechanical systems and are essential in many industries.

Comparison of Belt Drives, Chain Drives, Gears

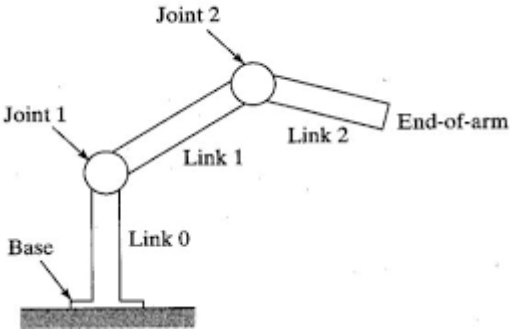
Aspect	Belt Drives	Chain Drives	Gears
Type of Transmission	Flexible	Flexible	Rigid
Mechanical Elements	Belts (usually rubber)	Chains (metal links)	Toothed wheels (gears)
Transmission Efficiency	Generally lower, as some energy is lost due to belt slippage.	Generally higher, with less energy loss compared to belt drives.	Very high, with minimal energy loss.
Noise Level	Quiet	Moderate to loud	Generally quiet
Maintenance	Low maintenance, but belts may wear out over time and need replacement.	Moderate maintenance, with chains requiring periodic lubrication and occasional replacement.	Low maintenance, with gears being durable and long-lasting.
Applications	Common in applications where shock absorption and flexibility are needed, like in some industrial machines and automotive engine accessories.	Used in various industrial machinery, bicycles, and motorcycles.	Common in precision machinery, automotive transmissions, and many mechanical systems requiring precise motion control.
Speed Variation	Limited speed variation, as it depends on the belt's material and tension.	Moderate speed variation due to different sprocket sizes.	Limited speed variation, as it depends on gear ratios.
Load Capacity	Generally lower load capacity compared to chain and gear drives.	Higher load capacity compared to belt drives.	High load capacity due to the rigid nature of gears.
Size and Weight	Lightweight and compact, suitable for space-constrained applications.	Moderately lightweight but bulkier compared to belts.	Compact, but the size may vary depending on gear type.
Cost	Generally cost-effective and cheaper to replace belts when worn out.	Moderately cost-effective, with occasional costs for chain replacement and lubrication.	Can be more expensive initially, but they have a longer lifespan and require less frequent replacement.

Introduction to Robotics

Robotics is a multidisciplinary field that deals with the design, construction, operation, and application of robots. Robots are machines or autonomous systems designed to perform tasks either autonomously or under human control. To understand the basics of robotics, it's essential to explore key components, configurations, and applications.

1. Joints and Links:

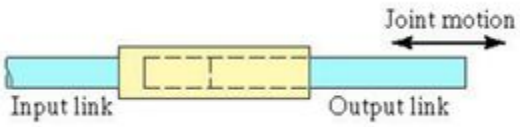
- **Links:** In robotics, a "link" is a rigid or semi-rigid component that connects various parts of a robot. Links can vary in shape and size, and they are often connected by joints.



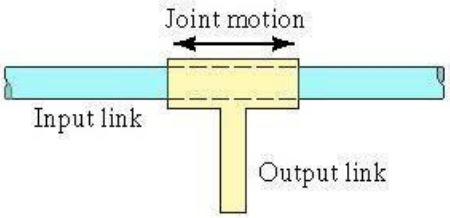
- **Joints:** Joints are the articulation points or connections between two adjacent links in a robot's structure. Joints allow relative motion between these links. There are various types of joints used in robotics, including:

Translatory motion:

✓ Linear joint: A linear joint provides straight-line motion, allowing a robot's end-effector or component to move along a single axis in a linear, back-and-forth fashion.



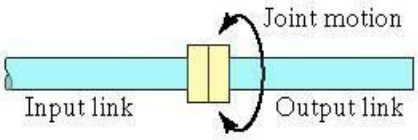
✓ Orthogonal joint (type O): An orthogonal joint enables motion at a right angle to the current direction, allowing a robot's parts to move perpendicular to their current orientation, commonly used for articulation between two intersecting axes.



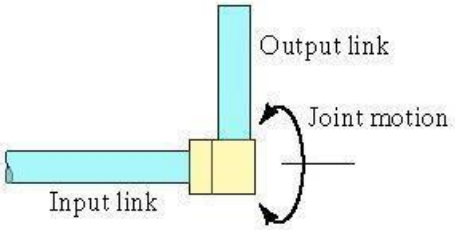
Rotary Motion:

Twisting joint:

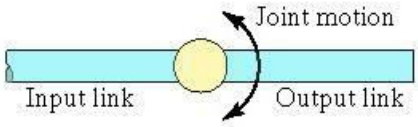
A twisting joint, or type T joint, enables rotational motion around a single axis, allowing a robot's component to twist or spin in place without translation.



Revolute Joint (R): Also known as a rotary joint, it allows rotational motion about a single axis, similar to a hinge.



Rotational joint: A rotation joint enables a robot's component to pivot or spin around a specific axis, providing angular motion without linear translation.

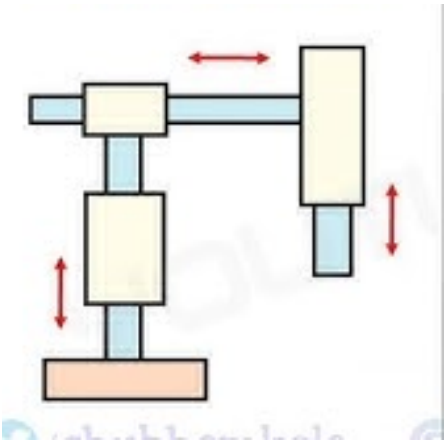


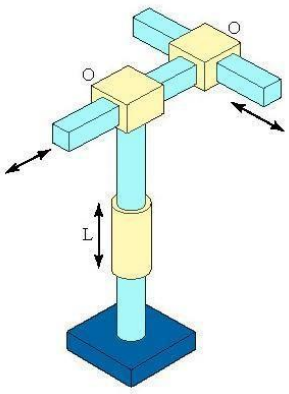
Robot Configurations

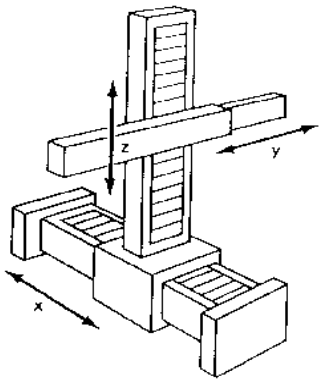
Robot configurations refer to the arrangement and type of joints that define a robot's movement capabilities and workspace. Each configuration offers varying degrees of flexibility, precision, and complexity, making them suitable for different industrial applications. Below are the types of robot configurations based on their joint arrangements and movement capabilities:

1. Cartesian Robot (3 Prismatic Joints)

- **Configuration:** A Cartesian robot consists of three linear (prismatic) joints that move along the X, Y, and Z axes. All the motions are linear, giving the robot a **rectangular or cuboid**-shaped working envelope.
- **Movement:** The robot's end-effector moves in a straight line along each axis. It is highly precise and simple to control because the motion in each direction is independent.
- **Applications:** Used in applications requiring precise positioning such as CNC machines, 3D printers, pick-and-place operations, and material handling tasks.



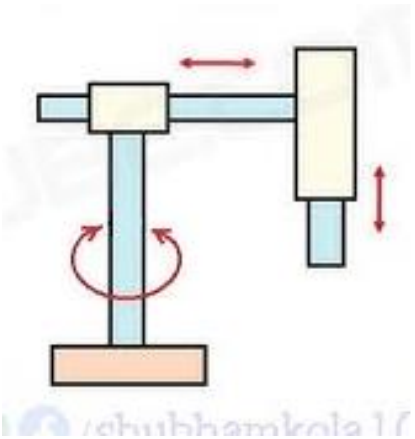


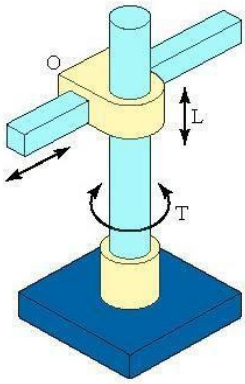


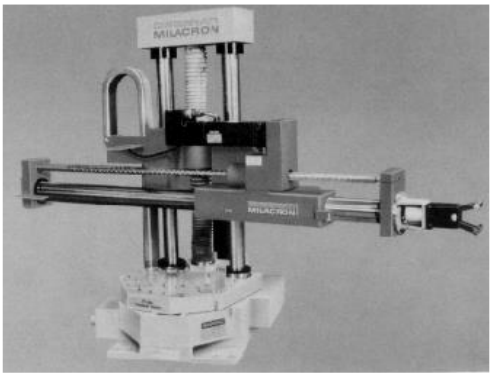
(Note: In the Exam the first diagram must be drawn- for all configurations & other two diagrams for understanding)

2. Cylindrical Robot (1 Revolute Joint 2 Prismatic Joints,)

- **Configuration:** A cylindrical robot has two prismatic joints (for linear movements along the radial direction and vertical axis) and one revolute joint (allowing rotation around a fixed axis).
- **Movement:** The prismatic joints control the linear motion, while the revolute joint allows the robot to rotate around a vertical axis. The workspace is shaped like a **cylinder.**
- **Applications:** Widely used in tasks like assembly, welding, and material handling in constrained spaces.

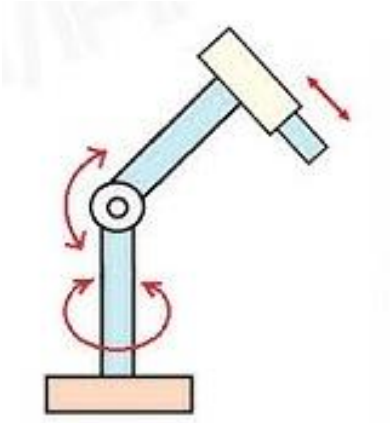


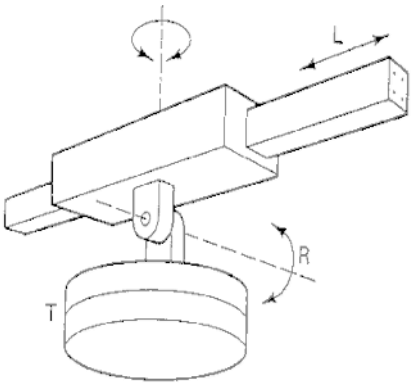


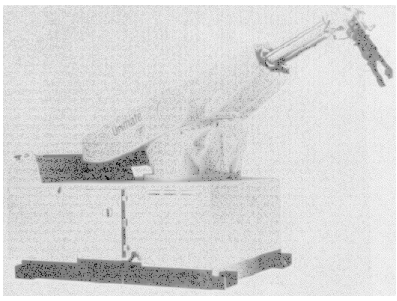


3. Spherical Robot (2 Revolute Joints, 1 Prismatic Joint)

- **Configuration:** A spherical robot consists of one prismatic joint (providing linear motion) and two revolute joints (providing rotational movements). It has a **spherical work envelope**.
- **Movement:** The prismatic joint allows the end-effector to move linearly, while the revolute joints enable rotation in two axes, giving the robot the ability to perform a wide range of motions within a spherical space.
- **Applications:** Used in tasks such as welding, painting, and handling tools in a wide range of orientations.



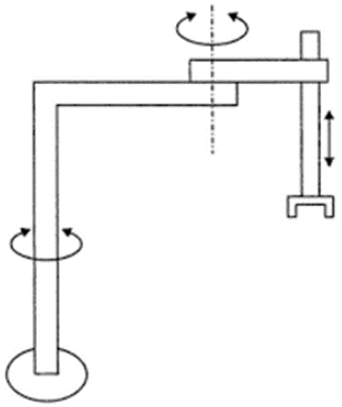


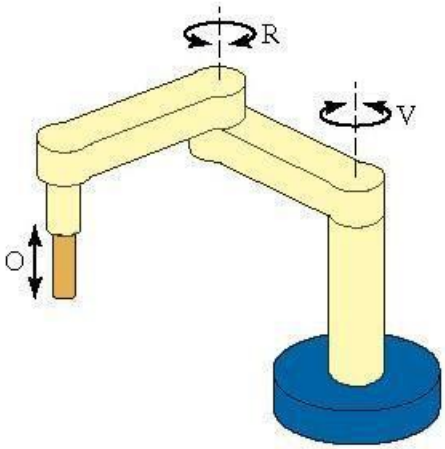


4. Selective Compliance Assembly Robot Arm - SCARA (2 Revolute Joints, 1 Prismatic Joint)

- **Configuration:** A SCARA robot has two revolute joints (allowing rotation in the horizontal plane) and one prismatic joint (providing vertical linear movement). The configuration gives the robot an **almost cylindrical work envelope**.
- **Movement:** The revolute joints provide horizontal arm movement, allowing the robot to reach different positions, while the prismatic joint enables vertical positioning.

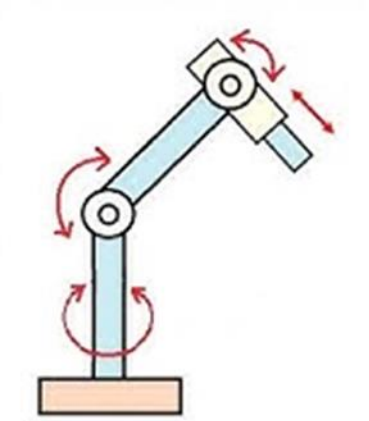
- **Applications:** Common in pick-and-place tasks, assembly operations, and precision manufacturing tasks like PCB assembly.

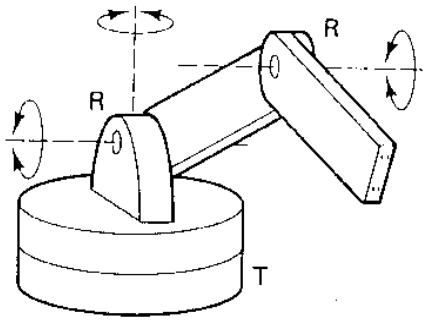




5. Articulated Arm Robot or Jointed-arm Robot (3 Revolute Joints)

- **Configuration:** The articulated arm robot features three or more revolute joints, providing a high degree of flexibility and allowing motion similar to a human arm. It can move in various directions, covering a wide and complex work envelope.
- **Movement:** Each revolute joint contributes to rotational movement, giving the robot the ability to reach many points within its range, with varying degrees of freedom depending on the number of joints.
- **Applications:** Used in welding, painting, assembly, packaging, and other applications requiring complex and flexible movements.
- **Advantages:** High flexibility, able to reach around obstacles, and handle complex motions with ease, mimics the movement of human arms for advanced tasks.
- **Disadvantages:** More complex control system, expensive, and can be slower compared to simpler robots like SCARA or Cartesian robots.





Applications of Robotics:

Robotics has a wide range of applications across various industries, including:

- **Manufacturing:** Robots are extensively used in manufacturing processes for tasks like welding, painting, assembling, and packaging. Industrial robots increase efficiency, accuracy, and safety.
- **Healthcare:** Robots are employed in surgery, rehabilitation, and diagnostics. Surgical robots, for example, assist surgeons in performing minimally invasive procedures with greater precision.
- **Agriculture:** Agricultural robots help with tasks like planting, harvesting, and monitoring crops. They improve productivity and reduce labor requirements.
- **Space Exploration:** Robots like rovers and landers are used in space exploration missions to collect data, conduct experiments, and explore other planets.
- **Logistics and Warehousing:** Autonomous mobile robots are employed in warehouses to transport goods, manage inventory, and optimize supply chain operations.
- **Service and Social Robots:** Robots designed for tasks like cleaning, delivery, customer service, and companionship are becoming more common in public spaces and homes.
- **Defense and Security:** Military and law enforcement agencies use robots for bomb disposal, reconnaissance, and surveillance in hazardous environments.
- **Education and Research:** Robotics is a valuable educational tool and is widely used in research for studying human-robot interaction, machine learning, and artificial intelligence.
- **Entertainment and Gaming:** Robots are used for entertainment purposes, such as theme park attractions and interactive exhibits.
- **Material handling:** Automated Guided Vehicles (AGVs) and Autonomous Mobile Robots (AMRs) transport materials, parts, and components within factories and between production lines.
- **Quality control and inspection:** Vision systems and robots equipped with cameras inspect vehicles for defects, ensuring high-quality production.
- **Power Train:** Robots assemble engine components, such as cylinder heads, pistons, and crankshafts.
- **Marine application:** Remotely Operated Vehicles (ROVs) are used for inspecting and maintaining underwater structures such as pipelines, oil rigs, and ship hulls.