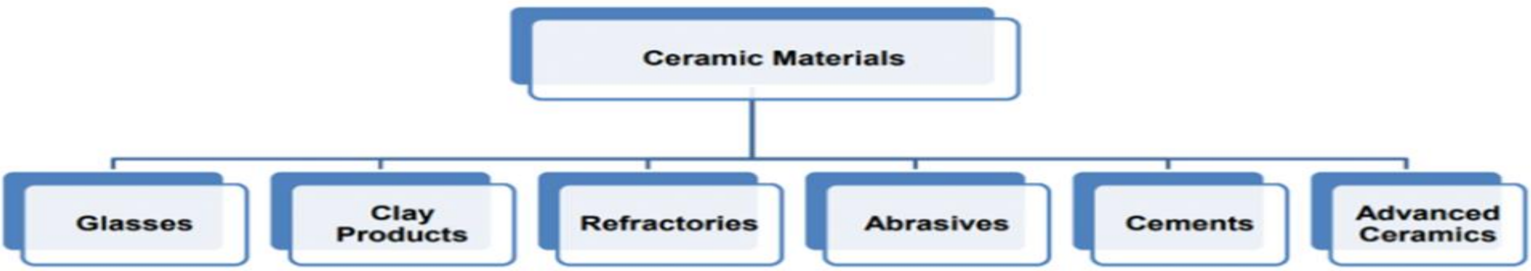
Part A (Short Answer Questions 5 x 2 = 10 Marks)

1. What are Ferrous Metals
   Ferrous metals contain iron. Examples are cast iron, mild steel, medium carbon steel, high carbon steel, stainless steel, and high speed steel.
2. List any two applications of nanomaterials
   Nanomaterials are used in filters, insulation and lubricant additives
   In the sports industry, lighter bats to have been produced with carbon nanotubes to improve performance.
3. What is smart manufacturing
   smart manufacturing refers to the use of advanced technologies and data-driven insights to improve efficiency, productivity and responsiveness in manufacturing processes.
4. What are the components of Electric and Hybrid Vehicles
   components of Electric and Hybrid Vehicles are electric motor, battery, convertor, IC Engine, fuel tank and control board.
5. List any two applications of wire ropes
   lifting and hoisting in cranes and elevators, and for transmission of mechanical power.

Part B (Long Answer Questions 3 x 10 = 30 Marks)

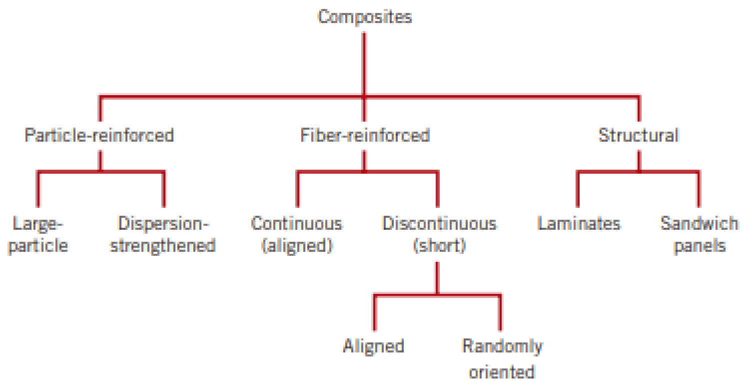
6. Explain about Ceramics, composite materials and Smart materials

Ceramics: The word "ceramic" is derived from the Greek word keramikos meaning pottery. "Ceramics can be defined as inorganic, non-metallic materials that are typically produced using clay and other minerals from the earth or chemically processed powders."



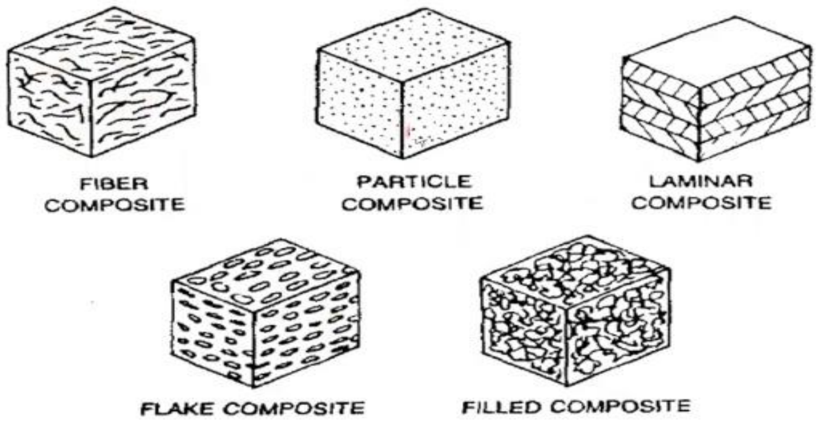
A ceramic is any of the various hard, brittle, heat-resistant, and corrosion-resistant materials made by shaping and then firing an inorganic, nonmetallic material, such as clay, at a high temperature. Common examples are earthenware, porcelain, and brick. The earliest ceramics made by humans were pottery objects (pots, vessels, or vases)

Composites also called a composition material are simply a combination of two or more constituent materials with different physical or chemical properties. When combined, they produce a material with characteristics different from their original properties. The two main components within a composite are the matrix and fiber



Composite materials are generally used for buildings, bridges, and structures such as boat hulls, swimming pool panels, racing car bodies, shower stalls, bathtubs, storage tanks, imitation granite, and cultured marble sinks and countertops. They are also being increasingly used in general automotive applications.

The most advanced examples perform routinely on spacecraft and aircraft in demanding environments.



- **Particle-reinforced composites:** Use particles as the reinforcing phase.
- **Large particle composites:** Particles are treated at a continuum level (e.g., concrete).
- **Dispersion-strengthened composites:** Tiny, dispersed particles strengthen the material at the atomic or molecular level (e.g., thoria-dispersed nickel).
  Fiber-reinforced composites: Use fibers to provide strength and stiffness.
- Classified by fiber orientation: continuous (orderly alignment) or discontinuous (aligned or randomly arranged).
  Structural composites: Combine different homogeneous and composite materials based on geometry.
- **Laminar composites:** Made of stacked, cemented sheets (e.g., plywood).
- **Sandwich composites:** A lightweight core is placed between two strong face sheets (e.g., used in walls and roofs).

Smart materials, also called intelligent or responsive materials are designed materials that have one or more properties that can be significantly changed in a controlled fashion by external stimuli, such as stress, moisture, electric or magnetic fields, light, temperature, pH, or chemical compounds.

Smart materials have properties that react to changes in their environment. This means that one of their properties can be changed by an external condition, such as temperature, light, pressure, electricity, voltage, pH, or chemical compounds. This change is reversible and can be repeated many times. There is a wide range of different smart materials. Each offer different properties that can be changed. Some materials are very good and cover a huge range of the scales.

There are a number of types of smart material, of which are already common. Some examples are as following:

- **Photovoltaic materials** or **optoelectronics** convert light to electrical current.
- **Electroactive polymers (EAPs)** change their volume by voltage or electric fields.
- **pH-sensitive polymers** are materials that change in volume when the pH of the surrounding medium changes.
- **Temperature-responsive polymers** are materials which undergo changes upon temperature.
- **Photomechanical materials** change shape under exposure to light.

7 (a) Explain the role of Mechanical Engineering in Industries

Role of Mechanical Engineering in Industries

Knowledge of Mechanical Engineering in the industry helps to do the following

- Analyze the test results and change the design or system as needed
- Develop and test prototypes of devices they design
- Investigate equipment failures or difficulties to diagnose faulty operation and to recommend remedies
- Design or redesign mechanical and thermal devices or subsystems, using analysis and computer-aided design
- Analyze problems to see how mechanical and thermal devices might help solve a particular problem
- Oversee the manufacturing process for the device

- Mechanical engineering is one of the broadest engineering fields. Mechanical engineers design and oversee the manufacture of many products ranging from medical devices to new batteries.

7 (b) Explain the emerging trends and technologies in Energy sector and Manufacturing sector

Energy sector: Mechanical engineers in the energy industry design and operate fossil fuel, hydroelectric, conventional, nuclear, and cogeneration power plants. They are involved in all aspects of the production and conversion of energy from one form to another.
Mechanical engineers are also involved in exciting projects such as developing alternatives to thermal energy, power cycle devices, fuel cells, gas turbines, and innovative uses of coal, wind, and tidal flow.

Increased efficiency in the solar PV cells, newer innovations in the electric vehicles.

Manufacturing industry: A majority of the roles in this sector are focused on supply network logistics/operations or manufacturing/ engineering. The jobs in this sector are not demarcated in different compartments. The jobs here are a mix of different engineering disciplines.
Manufacturing is the process of converting the raw material into a finished product. The technology had taken a great leap in the manufacturing sector. Along with side of conventional manufacturing methods other manufacturing methods are also practicing in the industry. Lean manufacturing, just in time manufacturing (JIT), Flexible manufacturing system (FMS), Computer Integrated manufacturing (CIM) are already in use. Along with this additive manufacturing is getting its importance in the new product development which reduces the material and time.

8 (a) Explain about the forming and joining Processes with a neat sketch

Rolling: a rolling process, the metal is passed through a series of roller to reduce the thickness and then give the desired shape

The rolling process consists of two or more two rollers in a combination with the metal plate. In regards to the rolling process, the metal plates are passed between the combination of two or more two rollers to make the metal plates thin and smooth surface finish.

The main purpose of the rolling process is to reduce the thickness of the metal plates. In the forming processes, metal is not removed. Hence, before the rolling process starts, less width metal is taken as per the need. After the rolling process the width is increased due to pressing and decreasing the thickness.

Extrusion: It is a process in which a metal is forced into a die to create a continuous path.

The extrusion process is much different from other processes. In this process, the metal is heated at high temperatures. Then the metal is pressed by the comprehensive force of the die.

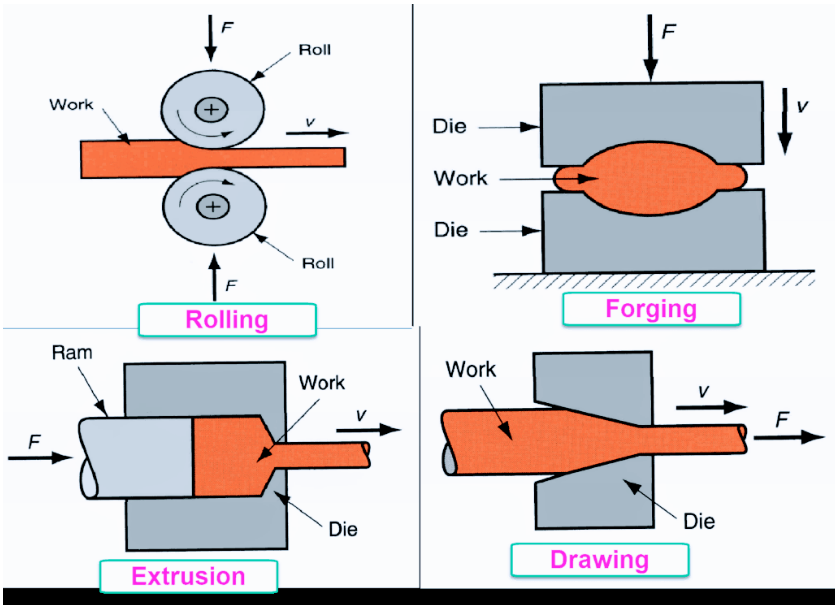
The die has an opening, through which the heated metal flows at the time of pressing by RAM. Hence, the proper shape can be made. In the extrusion process, the metal is heated at an extremely high temperature such that it becomes like a fluid.

Forging: In this the metal is heated and then it is given a shape using a compressive force.

At first, the metal is heated at a very high temperature. Then this metal is placed in a die. After that, the compressive force is applied to the heated metal so that the metal can get the shape of the die by deformation. Hence, the metal takes its shape by deformation.

Wire Drawing:

Here a wire-shaped die is used. The workpiece is passed through the die and takes the cross-section of the die opening. It is a pull process.



Joining: In joining, two or more pieces are joined together to produce the required product. Different methods are used for joining two or more parts together. The main joining processes used in industry today are welding, brazing, braze welding, soldering, adhesive bonding, Resin bonding and mechanical fasteners (including nut-bolt, nail, hook, clip, clutch, button, zipper, etc.).

Soldering is a process of joining two metal surfaces together using a filler metal called solder. The soldering process involves heating the surfaces to be joined and melting the solder, which is then allowed to cool and solidify, creating a strong and durable joint.

Soldering takes place at a temperature below 840°F (450°C). Soldering operates at lower temperatures and is commonly used for electronics and delicate components.

Welding is a fabrication process whereby two or more parts are fused together by means of heat, pressure or both forming a join as the parts cool. Welding is usually used on metals and thermoplastics but can also be used on wood. The completed welded joint may be referred to as a weldment.

Mechanical Fastening This involves joining parts together using mechanical elements like screws, bolts, nuts, rivets, or other types of fasteners. It is a reversible process.

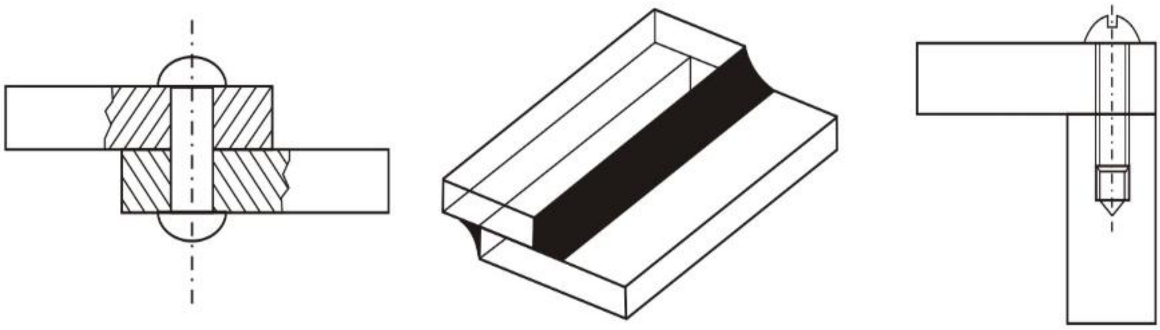


Fig. 1.2 Various joining methods (a) Riveting (b) Welding (c) Fastening

8 (b) Explain about 3D Printing

3D printing or additive manufacturing is the construction of a three-dimensional object from a CAD model or a digital 3D model. It can be done in a variety of processes in which material is deposited, joined or solidified under computer control, with the material being added together (such as plastics, liquids or powder grains being fused), typically layer by layer. 3D printing needs to go through the following four steps: modeling, slicing, printing, and post-processing.

3D printing Applications: 3D printing is used to manufacture moulds for making jewelry, and even the jewelry itself. 3D printing is becoming popular in the customisable gifts industry, with products such as personalized models of art and dolls, in many shapes: in metal or plastic, or as consumable art, such as 3D printed chocolate.

3D printing is used in various industries for rapid prototyping, customized manufacturing, and the production of complex or low-volume parts. Its applications span aerospace, healthcare, automotive, architecture, and many other fields.

The following steps outline the typical 3D printing process:

Designing the 3D Model:

The process begins with the creation of a digital 3D model using computer-aided design (CAD) software. This model defines the geometry and specifications of the object to be printed.

File Preparation:

The 3D model is then converted into a format that the 3D printer can understand. This is typically done by slicing the model into thin layers using slicing software. The resulting file, often in G-code format, contains instructions for the printer regarding the layer-by-layer construction of the object.

Material Selection:

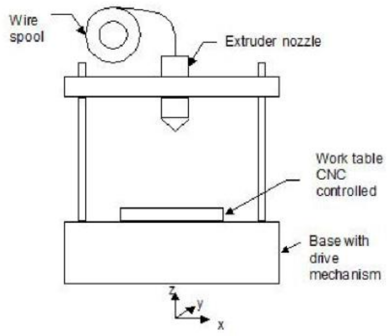
Different 3D printers use various materials, including plastics, metals, ceramics, and even biological materials. The choice of material depends on the specific requirements of the object being printed, such as strength, flexibility, or heat resistance.

Printer Setup:

The 3D printer is prepared for the printing process. This involves calibrating the printer, ensuring that the print bed is level, and loading the chosen printing material into the machine.

Printing: The 3D printer starts the printing process by depositing or solidifying material layer by layer according to the instructions in the G-code file. The specific technique varies based on the type of 3D printer and the material used. Common techniques include Fused Deposition Modeling (FDM), Stereolithography (SLA), Selective Laser Sintering (SLS), and others.

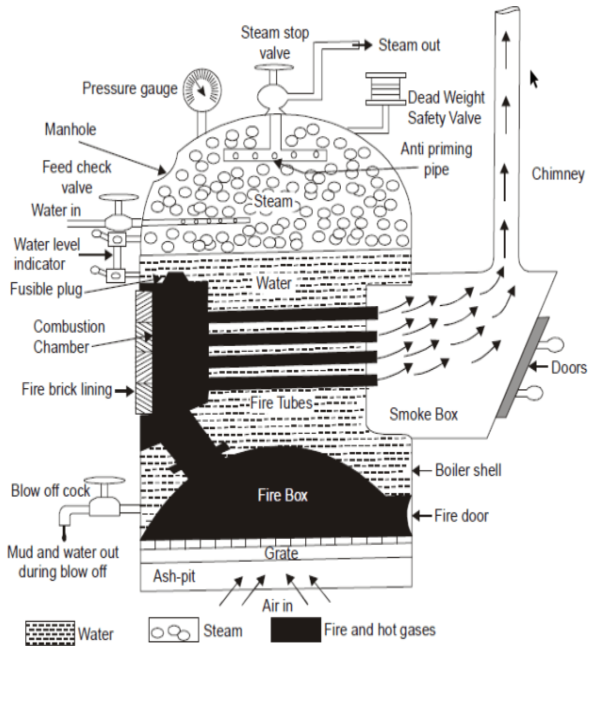
Layer-by-Layer Construction:
The 3D printer builds the object by adding successive layers of material. Each layer adheres to the previous one, gradually forming the final three-dimensional object.
Support Structures (if needed):
In some cases, especially for objects with overhangs or complex geometries, support structures may be added during the printing process to prevent the material from sagging or collapsing.
Cooling and Solidification:
Depending on the material, cooling or curing may be necessary between layers to ensure proper solidification and structural integrity of the printed object.
Post-Processing:
Once the printing is complete, the printed object may undergo post-processing steps such as removing support structures, surface finishing (polishing or sanding), and additional treatments to meet specific requirements.
Inspection and Quality Control:
The finished object is inspected to ensure it meets the desired specifications and quality standards.



9 (a) Explain about working principle of Boilers with a neat sketch

COCHRAN BOILER

It is a Vertical drum axis, natural circulation, natural draft, multi tubular, low pressure, solidfuel fired fire tube boiler with internally located furnace.
Working of the Cochran boiler: Coal is fed into the grate through the fire hole and burnt. Ash formed during burning is collected in the ash pit provided just below the grate and then itis



removed manually. The host gases from the grate pass through the flue pipe to the combustion chamber. The hot gases from the combustion chamber flow through the horizontal fire tubes and transfer the heat to the water by convection. The flue gases coming out of fire tubes pass through the smoke box and are exhausted to the atmosphere through the chimney. Smoke box is provided with a door for cleaning the fire tubes and smoke box.

Advantages of Cochran Boiler

- Low initial installation cost.
- It requires less floor area.
- Easy to operate and handle.
- Transportation of Cochran boiler is easy.
- It can use all types of fuel.

Disadvantages of Cochran Boiler

- Low rate of steam generation.
- Inspection and maintenance is difficult.

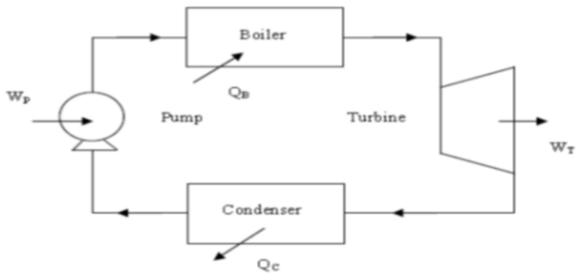
9 (b) Difference between two-stroke and four-stroke engine

Two Strokes	Four Strokes
It has one revolution of the crankshaft during one power stroke.	It has two revolutions of the crankshaft during one power stroke.
It generates high torque.	It generates less torque.
It uses a port for the fuel's outlet and inlet.	It uses valves for the fuel's outlet and inlet.
a lighter flywheel can be used	heavier flywheel is needed
Lower volumetric efficiency	Higher volumetric efficiency
Thermal efficiency is lower	Thermal efficiency is higher
It has a larger ratio in terms of power to weight.	It has a lesser ratio in terms of power to weight.
Due to poor lubrication, more wear and tear occurs.	Less wear and tear occurs.
Engines are cheaper and are simple to manufacture.	Engines are expensive and are tough to manufacture.
Used where low cost, compactness and light weight are important, viz., in mopeds, scooters, motorcycles, hand sprayers etc.	Used where efficiency is important, viz., in cars, buses, trucks, tractors, industrial engines, aero planes, power generation etc.

10. Explain the working of Steam and Hydro Electric Power Plant with a neat sketch

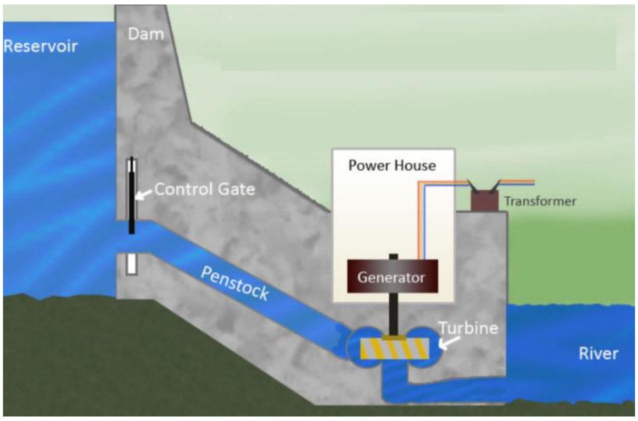
A steam power plant consists of a boiler, steam turbine and generator, and other auxiliaries. The boiler generates steam at high pressure and high temperature. The steam turbine converts the heat energy of steam into mechanical energy. The generator then converts the mechanical energy into electric power.

1. **Boiler:** The boiler is responsible for heating water to generate steam. This is typically achieved by burning fossil fuels (such as coal, oil, or natural gas) or by using nuclear energy. The generated steam is at high pressure and temperature.
2. **Turbine:** It is the mechanical device which converts the kinetic energy of the steam to the mechanical energy.
3. **Generator:** It is coupled with the turbine rotor and converts the mechanical energy of the turbine to the electrical energy.
4. **Condenser:** After passing through the turbine, the steam is directed to the condenser. Here, the steam is cooled and condensed back into water, releasing its latent heat. Condenser:
   It condensate the steam that leaves out turbine. It converts the low pressure steam to water. It is attached to the cooling tower.



Hydro Electric Power Plant: Generally, the hydroelectric power plants are installed in hilly areas where dams can be built and large water reservoirs can be obtained. In a hydroelectric power plant, the water head is created by constructing a dam across a river. Near the bottom of the dam wall there is the water intake. Gravity causes it to fall through the penstock inside the dam. At the end of the penstock there is a turbine propellor, which is turned by the moving water. The water turbine converts the hydraulic energy of the falling water into mechanical energy. The shaft from the turbine goes up into the generator, which converts the mechanical energy of the turbine into electrical energy, which produces the power.

Applications: can generate power to the grid immediately, they provide essential backup power during major electricity outages or disruptions. Hydropower provides benefits beyond electricity generation by providing flood control, irrigation support, and clean drinking water.



11. Explain about robot Joints & links, configurations with a neat sketch

Joints and Links

Links: The links are the rigid members connecting the joints.

The joints (also called axes): are the movable components of the robot that cause relative motion between adjacent links.

Joints and Links: The manipulator of an industrial robot consists of a series of joints and links. A robotic joint provides relative motion between two links of the robot. Each joint, or axis, provides a certain degree- of-freedom (dof) of motion. In most of the cases, only one degree-of freedom is associated with each joint.

Therefore, the robot's complexity can be classified according to the total number of degrees-of-freedom they possess. Each joint is connected to two links, an input link and an output link. Joint provides controlled relative movement between the input link and output link. A robotic link is the rigid component of the robot manipulator. Most of the robots are mounted upon a stationary base, such as the floor. From this base, a joint-link numbering scheme may be recognized as shown in Figure 1. The robotic base and its connection to the first joint are termed as link-0. The first joint in the sequence is joint-1. Link-0 is the input link for joint-1, while the output link from joint-1 is link-1—which leads to joint-2. Thus link 1 is, simultaneously, the output link for joint-1 and the input link for joint-2. This joint-link- numbering scheme is further followed for all joints and links in the robotic systems

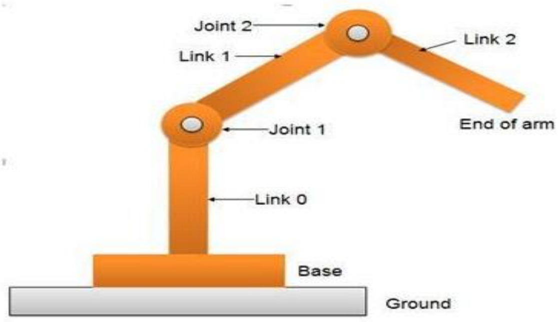


Fig. 1 Joint-link scheme for robot manipulator

Nearly all industrial robots have mechanical joints that can be classified into followingfive types as shown in Figure 2.

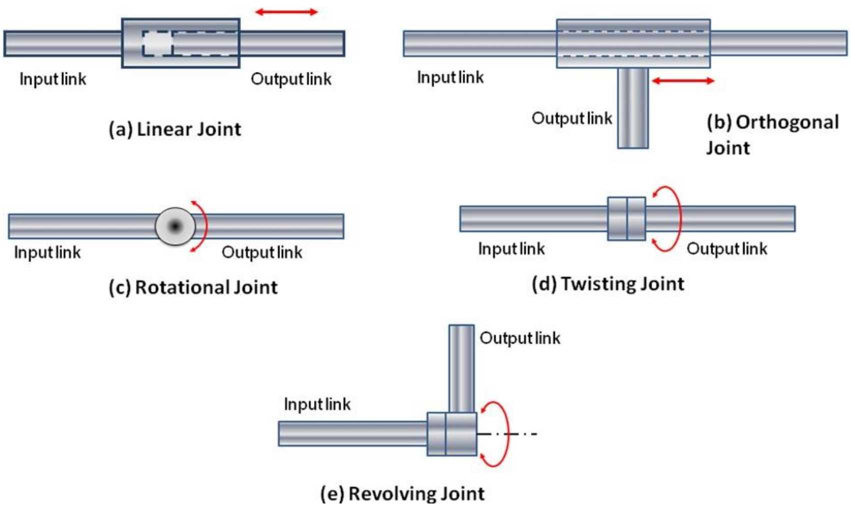


Fig. 2 Types of Joints

a) Linear joint (type L joint)

The relative movement between the input link and the output link is a translationalsliding motion, with the axes of the two links being parallel.

b) Orthogonal joint (type U joint)

This is also a translational sliding motion, but the input and output links areperpendicular to each other during the movement.

c) Rotational joint (type R joint)

This type provides rotational relative motion, with the axis of rotation perpendicular tothe axes of the input and output links.

d) Twisting joint (type T joint)

This joint also involves rotary motion, but the axis or rotation is parallel to the axes ofthe two links.

e) Revolving joint (type V-joint, V from the “v” in revolving)

In this type, axis of input link is parallel to the axis of rotation of the joint. However theaxis of the output link is perpendicular to the axis of rotation.

Robotic arm configurations:

For body-and-arm configurations, there are many different combinations possible fora three-degree-of-freedom robot manipulator, comprising any of the five joint types. Common body-and-arm configurations are as follows.

1) Polar coordinate arm configuration 2) Cylindrical coordinate arm configuration

3) Cartesian coordinate arm configuration 4) Jointed arm configuration

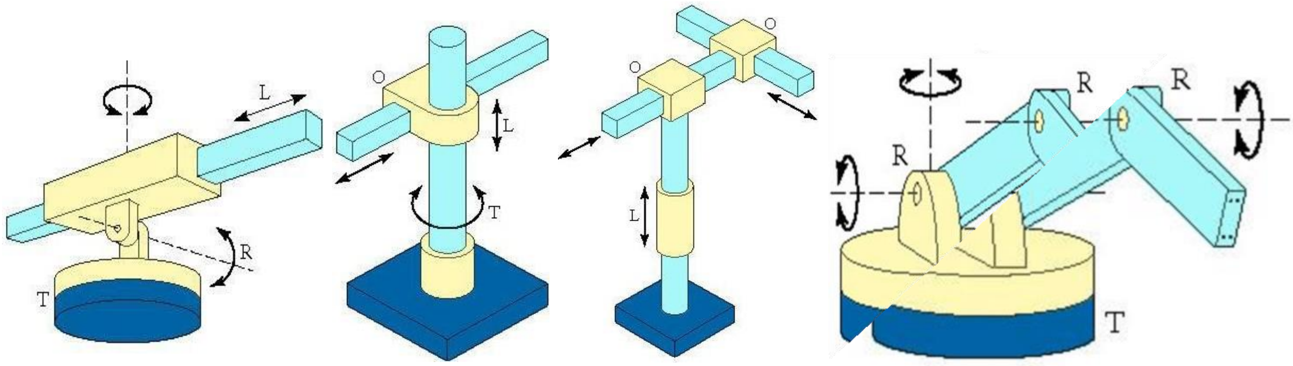


Fig 3: 3-dof polar arm configuration; Fig 4: 3-dof cylindrical arm configuration; Fig 5:3-dof Cartesian arm configuration; Fig 6. 3-dof jointed arm configuration

1) Polar coordinate arm configuration(RRP):

The polar arm configuration is shown in the fig 3. It consists of a prismatic joint that can be raised or lowered about a horizontal revolute joint. The two links are mounted on a rotating base. These various joints provide the capability of moving the arm endpoint within a partial spherical space. Therefore it is called as Spherical co-ordinate configuration. This configuration allows manipulation of objects on the floor.

Drawbacks:

i. Low mechanical stiffness
ii. Complex construction
iii. Position accuracy decreases with the increasing radial stroke.

Applications: Machining, Spray painting

2) Cylindrical coordinate arm configuration (RPP):

The cylindrical configuration uses two perpendicular prismatic joints and a revolute joint as shown in fig 4.This configuration uses a vertical column and a slide that can be moved up or down along the column. The robot arm is attached to the slide, so that it can be moved radially with respect to column. By rotating the column, the robot is capable of achieving a workspace that approximates a cylinder. The cylindricalconfiguration offers good mechanical stiffness.

Drawback: Accuracy decreases as the horizontal stroke increases.

Applications: suitable to access narrow horizontal capabilities, hence used formachine loading operations.

3) Cartesian coordinate arm configuration (PPP):

From fig 5. Cartesian coordinate or rectangular coordinate configuration is constructed by three perpendicular slides, giving only linear motions along the three principal axes. It consists of three prismatic joints. The endpoints of the arm are capable of operating in a cuboidal space. Cartesian arm gives high precision and is easy to program.

Drawbacks:

- limited manipulability
- low dexterity (not able to move quickly and easily)

Applications: use to lift and move heavy loads.

4) Jointed arm configuration (RRP) or articulated configuration:

From fig 6. jointed arm configurations are like that of human arm. It consists of two straight links, corresponding to human fore-arm and upper arm with two rotary joint corresponding to the elbow and shoulder joints. These two are mounted on a vertical rotary table corresponding to human waist joint. The work volume is spherical. This structure is the most dexterous one. This configuration is very widely used.

Applications: Arc welding, Spray coating.

Example: **SCARA** robot (Selective compliance Assembly Robot Arm)