

BASIC CIVIL AND MECHANICAL ENGINEERING

BASIC MECHANICAL ENGINEERING (PART – B) MATERIAL

UNIT-I SYLLABUS

Introduction to Mechanical Engineering: Role of Mechanical Engineering in Industries and Society- Technologies in different sectors such as Energy, Manufacturing, Automotive, Aerospace, and Marine sectors.

Engineering Materials: Metals-Ferrous and Non-ferrous, Ceramics, Composites, Smart materials.

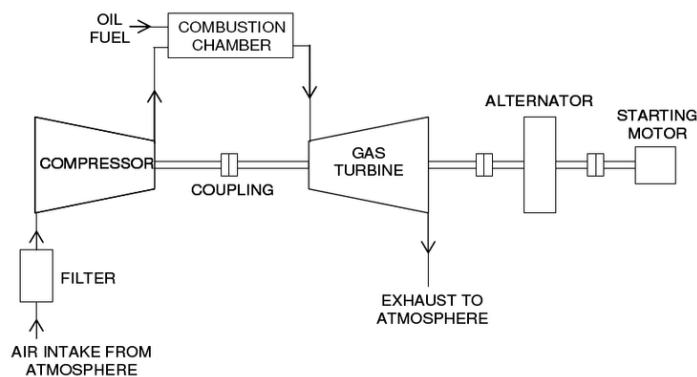
UNIT-I NOTES

1. Role of Mechanical Engineering in Industries and Society:

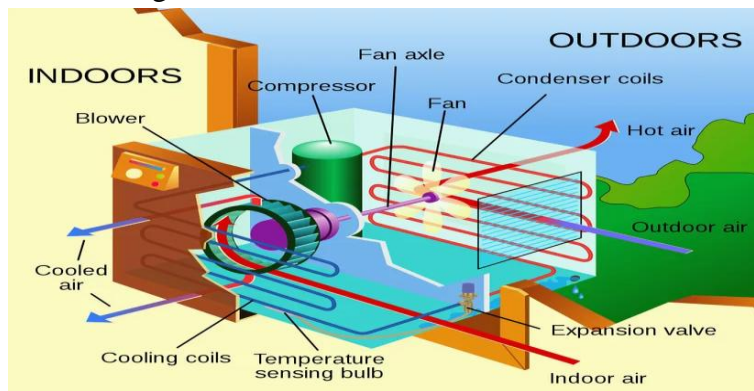
Mechanical engineers are involved in almost every aspect of human existence and welfare, including machines, cars and other vehicles, aircraft, power plants, automobile parts, and manufacturing plants etc. A Mechanical Engineer plays a significant role in designing, developing, and testing machines as well as thermal devices. It also includes systems that are essential to many aspects of modern society and Industries. They use their knowledge of mechanics, thermodynamics, materials science, and energy to create solutions that improve the quality of life of people.

Besides, the role of a mechanical engineer in our society is contributed as:

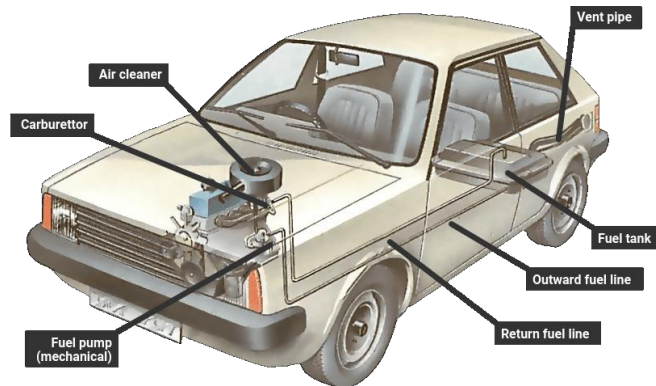
- **Power Generation:** Mechanical engineers design and develop power-generating machines such as internal combustion engines, gas turbines, and steam and wind turbines etc



- **Heating and Cooling Systems:** They design and develop heating, ventilation, refrigeration and air conditioning systems for buildings and other structures.



- **Transportation:** Mechanical engineers are involved in designing and developing transportation systems, including cars, trains, airplanes, steamers and boats.



- **Industrial Equipment:** They design, develop and maintain industrial equipment such as machine tools, robots, and conveyor systems & belts



- **Infrastructure:** Mechanical engineers play a key role in the design and maintenance of infrastructure, including buildings, bridges, roads, and transportation systems.



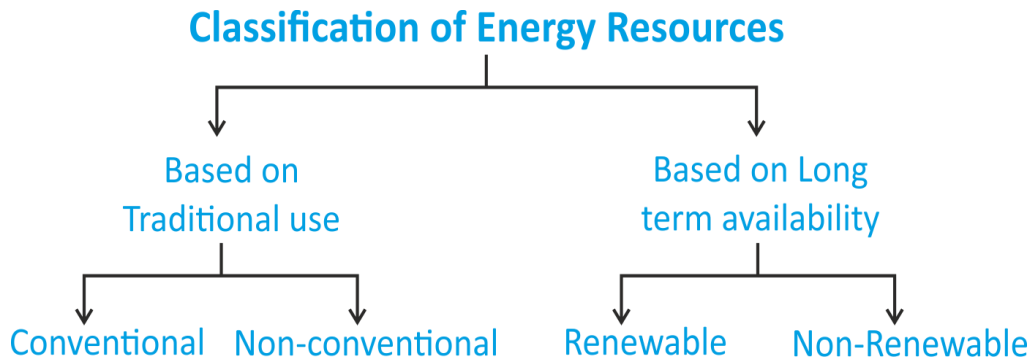
Overall, Mechanical Engineers are involved in designing, building, and maintaining the engines, machines, and structures that make modern life possible and comfortable.

They contribute to society by using their skills to improve the safety, security, efficiency, and comfort of the systems and devices that we rely on every day.

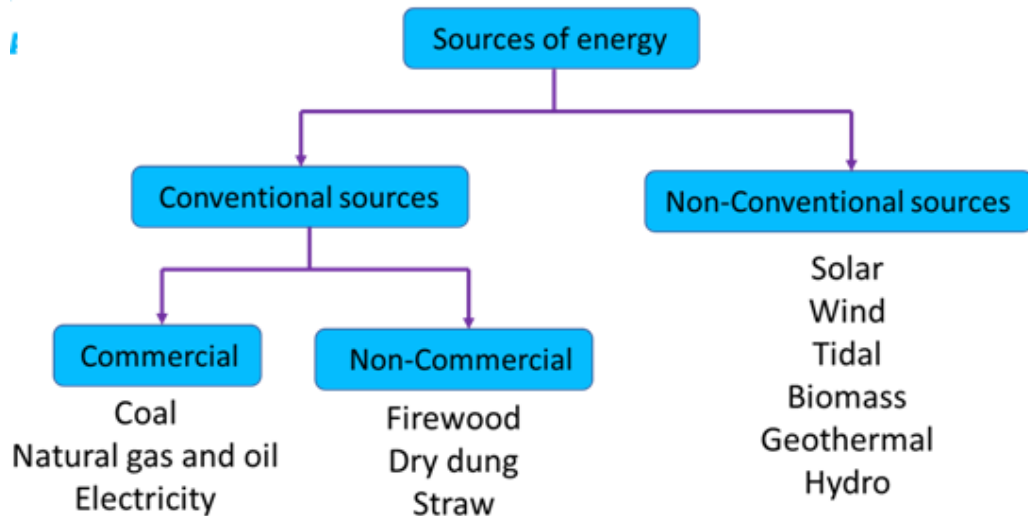
2. Technologies in different sectors:

2.1 Energy Sector:

Generally Energy Resources are classified according to TWO Types as below:



The Conventional and non-conventional resources are again classified in to broad classification like:



The differences between the conventional and non-conventional is shown below:

BASIS FOR COMPARISON	CONVENTIONAL SOURCES OF ENERGY	NON-CONVENTIONAL SOURCES OF ENERGY
Meaning	Conventional sources of energy are the sources that are commonly in use since long time.	Non-conventional sources of energy refers to the sources that are identified few decades ago.
Exhaustible	They can be exhausted due to over consumption.	They cannot be exhausted.
Pollution	They pollute environment, on a large scale and adds to global warming.	They are environment friendly sources, which does not causes pollution.

Criteria	Non-renewable energy resources	Renewable energy resources
Repetitively used energy sources	One-time use	Can use again and again
Perpetual sources	Vanish one day	Available for perpetual use
Eco-friendly sources	Emits gasses and pollute the environment	Do not emit gases and does not pollute the environment
Availability	Limited quantity	Unlimited quantity.
Production cost	High	Low
Maintenance cost	Low	High
Production quantity	Large	Less

Like most modern areas of technology, the energy sector is a highly multidisciplinary field, with contributions from mechanical, electrical, chemical, systems and other types of engineers helping to drive advances in renewable energy infrastructure.

Mechanical engineers can work in every stage of renewable energy development and distribution. From developing methods that lower the cost of manufacturing silicon for solar panels to designing more optimal ways to construct wind farms, mechanical engineers are critical to lowering the cost of renewable energy infrastructure and making advancements in efficiency and power generation. While not a comprehensive list, some of the essential duties of mechanical engineers in renewable energy include:

- Optimize existing renewable energy technology so that it becomes more cost efficient to develop related infrastructure.
- Systems integration of different renewable energy technologies
- Research different materials and study material interactions for use in renewable energy, potentially leading to the development of new systems, technologies and infrastructure for generating and distributing power.
- Consult on renewable energy development projects to guide organizations regarding the best approach for reaching their sustainability goals, such as by identifying technology needs, costs and other aspects related to investing and building renewable energy infrastructure.
- Lead teams of engineers and researchers to design and optimize renewable energy infrastructure and systems.
- Educate business decision makers, policymakers and other non-technical stakeholders on the viability of different approaches to sourcing and distributing renewable energy.

In addition to their contributions in the development of infrastructure and day-to-day operations of renewable energy, mechanical engineers make numerous contributions to the sector through research and development, addressing problems like how to reliably store energy for long periods of time and how to improve the design of equipment ranging from cooling systems to wind turbines.

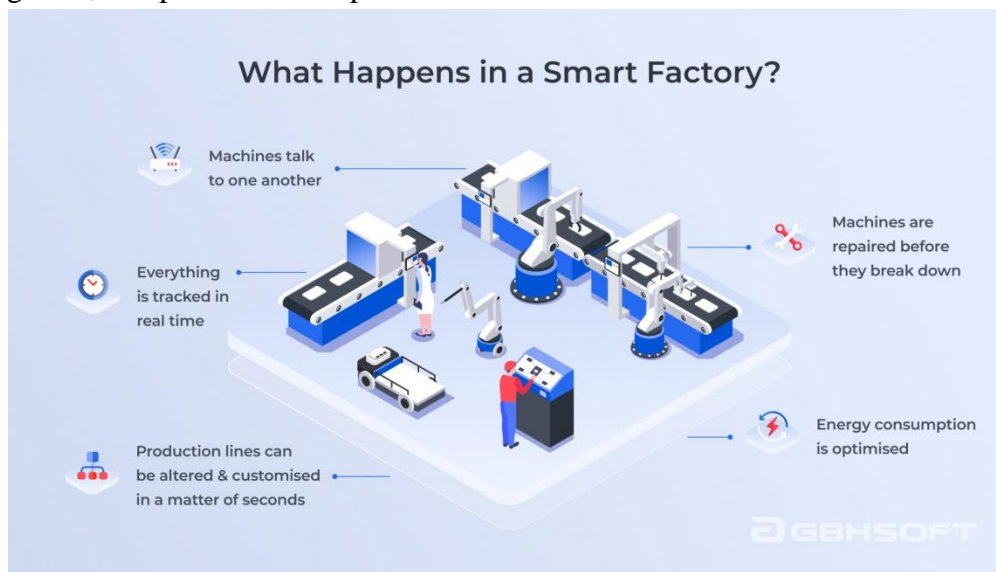


2.2 Manufacturing Sector:

There are many modern manufacturing technologies, most of them specifically relevant to ‘Industry 4.0’, the name given to the fourth industrial revolution, associated with automation, data exchange, digital technology, artificial intelligence and machine learning, and the ‘Internet of Things’. Therefore, a lot of the manufacturing technologies innovating production and industry are also relevant to this fourth wave of technological advancement.

Some of Manufacturing sector classifications:

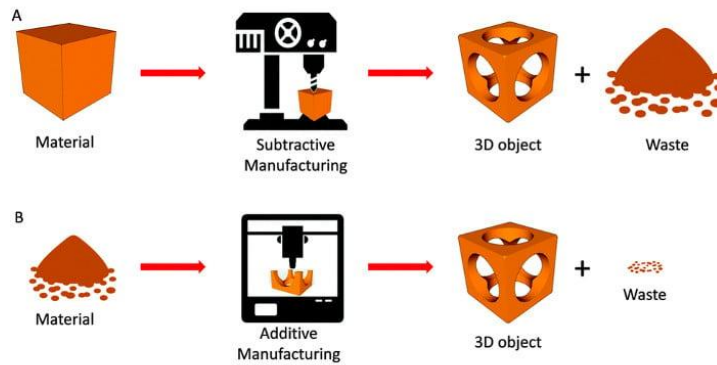
Smart Factories: Smart factories are environments that are highly digitized for manufacturing to take place more efficiently through connected systems. Through innovative manufacturing technology, machines and systems can, through automation and self-optimization, learn and adapt to situations with increased productivity. Facilities in France, Ireland, China, and the Czech Republic were named the most productive and powerful smart factories in the world by the World Economic Forum in 2019. Able to produce goods on a large scale, smart factories are useful not just for manufacturing jobs but also for processes like planning, supply chain logistics, and product development.



Cyber-physical systems: Cyber-physical systems are those which integrate computer, networking, and physical processes, in which embedded computing technologies control and monitor processes in real time. The combination of cyber and physical industries is crucial to this manufacturing technology; the computer system monitors the process and identifies areas where change is required, and the physical system reacts accordingly. Cyber-physical systems are often considered one of the main advancements of Industry 4.0.



Additive Manufacturing: 3D printing, also known as additive manufacturing, is a computer controlled process in which three-dimensional objects can be created by materials deposited in layers. Using computer aided design (CAD) or 3D object scanners, components, parts, or any other object can be made without the use of machining or any other techniques, and therefore less surplus material.

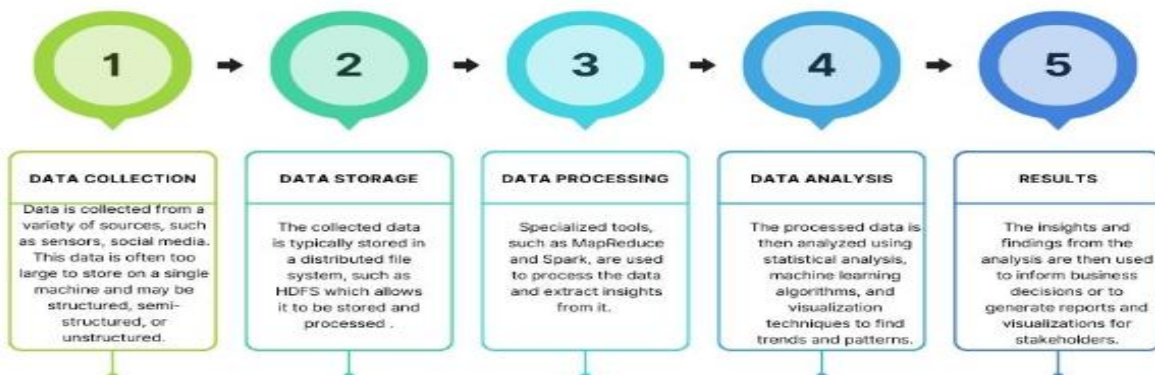


Big Data: Today data is collected constantly in systems, sensors, and commonplace electronic items like mobile devices, and the amount of data to be stored is growing every day. ‘Big data’, a collection of global data from various sources, can be a useful component in manufacturing technology. Industry is in the process of developing methods to interpret and analyse data to use in production. These potential productive uses include risk management, manufacturing products to a customer’s specific tastes or order, improving quality, tracking production, and logistics, amongst others.

Here are some more examples of how big data is used by organizations:

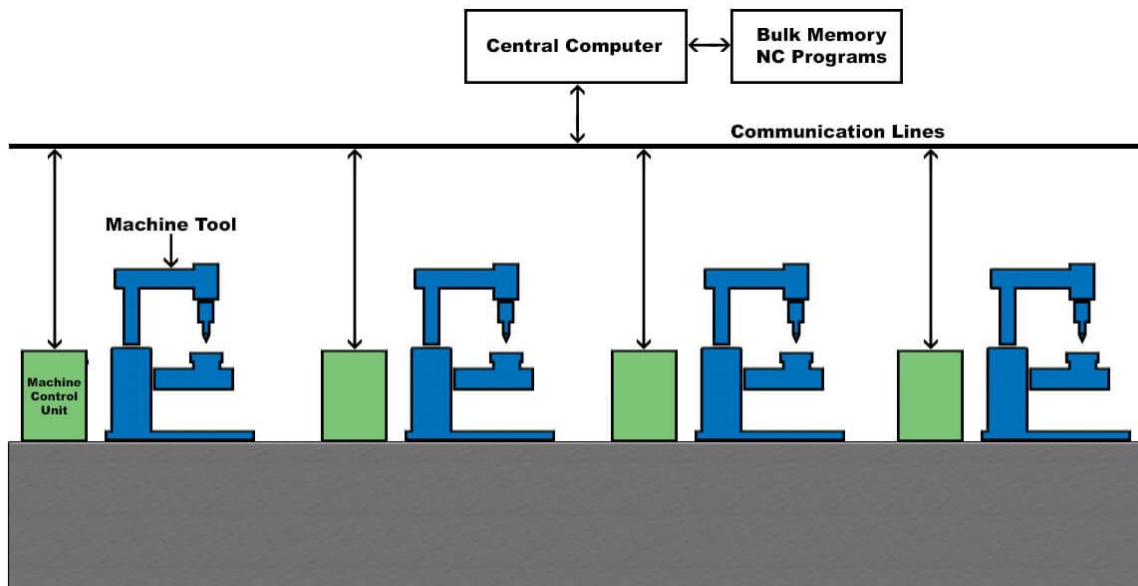
- In the energy industry, big data helps oil and gas companies identify potential drilling locations and monitor pipeline operations; likewise, utilities use it to track electrical grids.
- Financial services firms use big data systems for risk management and real-time analysis of market data.
- Manufacturers and transportation companies rely on big data to manage their supply chains and optimize delivery routes.
- Other government uses include emergency response, crime prevention and smart city initiatives.

How does big data analytics works? Management



Augmented Reality: Augmented reality (AR) technology displays digital content in the real world, allowing visualization of products or superimposing data or plans onto physical components and machinery. In manufacturing, AR could be used to overlay text, statistics, such as showing the running temperature of a piece of equipment without touching it, or virtual health and safety training without requiring an individual to involve themselves in something potentially harmful. Augmented reality glasses are predicted to reach around 19.1 million units by 2021, and when combined with virtual reality devices, could hit 59.2 million units.

Numerical Control: Machining tools or items used in manufacture, such as 3D printers, can be regulated and controlled remotely using CNC – computer numerical control. A CNC machine processes a piece of material to key specifications, following a coded programmed instruction and without the need for a manual operator. Modern CNC systems, through high tech computer programming, allows the design and manufacture of a mechanical part to be highly automated. Processes like laser cutting and additive manufacturing rely on numerical control to efficiently and remotely create products.



2.3 Technologies in Automotive sector:

Mechanical technologies play a crucial role in the automotive sector, impacting vehicle design, manufacturing, and operation. Here are some key mechanical technologies associated with the automotive industry:

1. Internal Combustion Engines (ICE): Traditional gasoline and diesel engines have seen ongoing advancements in efficiency, emissions reduction, and performance. Technologies include turbo charging, direct fuel injection, and variable valve timing.

2. Hybrid and Electric Power trains: The automotive sector has seen a shift towards hybrid and electric vehicles (EVs). Mechanical technologies in this area involve battery systems, electric motors, regenerative braking, and power management systems.

3. Transmission Systems: Advancements in automatic and manual transmissions aim to improve fuel efficiency and driving performance. Continuously Variable Transmissions (CVTs) and dual-clutch transmissions are examples of modern innovations.

4. Chassis and Suspension Systems: Mechanical engineers design chassis and suspension systems for ride comfort, handling, and safety. Innovations include adaptive suspension systems, air suspension, and lightweight materials for chassis construction.

5. Braking Systems: Brake technology is critical for vehicle safety. Advances in brake materials, electronic stability control, and anti-lock braking systems (ABS) improve stopping distances and control.

6. Tire Technology: Tires are engineered for performance, durability, and fuel efficiency. Advances include low-rolling-resistance tires, run-flat technology, and tire pressure monitoring systems (TPMS).

7. Fuel Injection Systems: Fuel injection systems have become more precise and efficient, contributing to improved fuel economy and reduced emissions. Direct fuel injection and gasoline direct injection (GDI) are examples of such technologies.

8. Emission Control: Emission control technologies, such as catalytic converters and exhaust gas recirculation (EGR) systems, are essential for reducing harmful emissions from internal combustion engines.

9. Materials and Light weighting: The automotive industry is continually exploring lightweight materials like carbon fiber, aluminum, and high-strength steel to reduce vehicle weight and improve fuel efficiency without sacrificing safety.

10. Automated Manual Transmissions (AMTs): AMTs combine the benefits of manual and automatic transmissions, offering improved fuel efficiency and ease of use. They are commonly used in commercial vehicles.

11. Active Safety Systems: Mechanical technologies underpin active safety features such as adaptive cruise control, lane-keeping assist, blind-spot monitoring, and collision avoidance systems.

12. Passive Safety Systems: Vehicle design includes crumple zones, airbags, and seatbelt systems to protect occupants in the event of a collision. These systems are continuously improved for enhanced safety.

13. Advanced Driver Assistance Systems (ADAS): ADAS technologies involve mechanical components like sensors, cameras, and radar systems that enable features such as automated parking, traffic jam assist, and highway autopilot.

14. Steering Systems: Power steering systems, including hydraulic and electric power-assisted steering (EPS), improve driver control and reduce steering effort.

15. Engine Cooling Systems: Efficient engine cooling is essential for preventing overheating. Radiators, cooling fans, and advanced cooling fluids contribute to engine reliability.

16. Exhaust Systems: Exhaust technology focuses on reducing noise and emissions while optimizing engine performance. Innovations include variable exhaust systems and particulate filters.

17. Suspension Control Systems: Active suspension systems and adaptive damping technologies enhance ride comfort and handling by adjusting suspension settings in real time.

18. HVAC Systems: Heating, ventilation, and air conditioning (HVAC) systems provide passenger comfort. Advanced systems incorporate zone control, air quality sensors, and efficient cooling technologies.

19. Manufacturing Automation: Mechanical robots and automated systems are used in vehicle manufacturing, improving precision and efficiency on the assembly line.

20. Additive manufacturing (3D Printing): 3D printing is used to create prototypes, customize components, and reduce waste in automotive manufacturing.

These mechanical technologies drive innovation and advancement in the automotive sector, leading to safer, more efficient, and environmentally friendly vehicles while also improving the driving experience for consumers.

2.4 Technologies in Aerospace sector:

Mechanical technologies are fundamental to the aerospace sector, ensuring the design, manufacturing, and operation of aircraft and spacecraft are safe, efficient, and reliable. Here are some key mechanical technologies associated with the aerospace sector:

1. Aircraft Design and Analysis: Mechanical engineers use advanced software tools for aircraft design and analysis, employing techniques such as finite element analysis (FEA) and computational fluid dynamics (CFD) to optimize aerodynamics, structural integrity, and performance.

2. Aircraft Structures: Lightweight yet strong materials like carbon composites and advanced aluminum alloys are used to construct aircraft structures. Manufacturing processes like additive manufacturing (3D printing) are employed for producing complex components.

3. Aircraft Propulsion: Mechanical technologies play a vital role in developing jet engines, turboprops, and other propulsion systems. Research focuses on increasing engine efficiency, reducing emissions, and improving reliability.

4. Aircraft Systems: Mechanical systems are integral to the operation of aircraft, including landing gear, hydraulic systems, and fuel systems. Innovations aim to enhance safety, durability, and performance.

5. Aircraft Avionics: Mechanical technologies contribute to the development of avionics components, including displays, control systems, and sensors. Advances in miniaturization and reliability are crucial for avionics systems.

6. Aircraft Interiors: Cabin design and ergonomics, including seats, ventilation systems, and cabin pressure control, are part of mechanical considerations to enhance passenger comfort and safety.

7. Aircraft Maintenance and Repair: Mechanical tools and equipment are used for aircraft maintenance, including aircraft jacks, diagnostic devices, and repair tools. Precision instruments are critical for ensuring the structural integrity of aircraft.

8. Unmanned Aerial Vehicles (UAVs): Mechanical technologies are used in the design and manufacturing of UAVs, including fixed-wing and multirotor drones, as well as in the development of payloads and control systems.

9. Spacecraft Structures: Spacecraft are subjected to extreme conditions, requiring advanced mechanical design and materials to withstand launch, space radiation, and re-entry. Deployable structures for solar panels and antennas are also crucial.

10. Space Propulsion: Mechanical technologies are essential for propulsion systems in spacecraft, whether chemical rockets, ion drives, or novel propulsion methods for deep space exploration.

11. Space Exploration Vehicles: Mechanical engineering plays a significant role in the design of space rovers, landers, and exploration vehicles used in planetary and lunar missions.

12. Space Station and Habitat Design: Mechanical systems are essential for the construction and maintenance of space stations like the International Space Station (ISS) and for designing habitats for future deep space missions.

13. Parachute Systems: For spacecraft re-entry and landing, parachute systems are critical. Mechanical technologies are used to develop and test these systems for precise landings.

14. Thermal Control: Spacecraft require sophisticated thermal control systems to manage extreme temperature variations in space. Mechanical systems, such as radiators and insulation, are essential for this purpose.

15. Aircraft and Spacecraft Testing: Mechanical engineers design and operate test facilities, such as wind tunnels, vibration testing rigs, and thermal chambers, to simulate and validate aircraft and spacecraft performance under various conditions.

16. Aircraft and Spacecraft Manufacturing: Advanced manufacturing processes, including precision machining, composite layup, and robotic assembly, are used in the production of aerospace components.

17. Additive manufacturing (3D Printing): 3D printing is increasingly used in aerospace to manufacture complex parts, reduce weight, and improve design flexibility.

18. Noise Reduction Technologies: Mechanical engineers work on noise-reduction technologies to make aircraft quieter, improving passenger comfort and reducing environmental impact.

19. Aircraft and Spacecraft Safety: Mechanical systems and technologies are integral to ensuring the safety of aircraft and spacecraft, including emergency systems, escape pods, and fire suppression systems.

These mechanical technologies in the aerospace sector are at the forefront of innovation, driving advancements in flight safety, efficiency, environmental sustainability, and exploration beyond Earth's atmosphere.

2.5 Technologies in Marine Sector:

Mechanical technologies play a crucial role in the marine sector, which encompasses a wide range of applications, from shipbuilding and propulsion systems to offshore drilling and underwater exploration. Here are some key mechanical technologies associated with the marine sector:

- 1. Ship Design and Construction:** Advanced computer-aided design (CAD) and computer-aided manufacturing (CAM) technologies are used to design and build ships efficiently. These technologies ensure that vessels are structurally sound, aerodynamically optimized, and meet safety and environmental standards.
- 2. Propulsion Systems:** Mechanical technologies in marine propulsion include the development of high-efficiency engines, such as diesel engines and gas turbines, as well as innovations like water-jet propulsion, pod propulsion systems, and hybrid or electric propulsion to improve fuel efficiency and reduce emissions.
- 3. Propeller Design:** Propeller technology continues to evolve to optimize thrust, reduce noise, and increase fuel efficiency. Computational fluid dynamics (CFD) simulations are used to design propellers that are tailored to specific vessel types and operational profiles.
- 4. Hull Design:** Advanced hull design incorporates hydrodynamics and materials science to reduce drag, improve stability, and enhance fuel efficiency. Special coatings and antifouling technologies help prevent marine growth on hulls, reducing resistance.
- 5. Underwater Robotics:** Remotely operated vehicles (ROVs) and autonomous underwater vehicles (AUVs) equipped with mechanical systems and sensors are used for tasks such as underwater exploration, research, maintenance of offshore infrastructure, and deep-sea mining.
- 6. Offshore Drilling Technology:** The offshore oil and gas industry relies on mechanical technologies like drilling rigs, drillships, and subsea equipment. Innovations in drill bit design, riser systems, and blowout preventers improve drilling efficiency and safety.
- 7. Marine Renewable Energy:** Mechanical technologies are essential for harnessing marine renewable energy sources such as tidal, wave, and ocean thermal energy. Turbines and generators are designed to withstand harsh marine environments.
- 8. Cranes and Lifting Equipment:** Cranes and lifting equipment are used for cargo handling, ship maintenance, and offshore operations. These systems are designed for heavy-duty lifting in challenging maritime conditions.
- 9. Navigation and Communication:** Mechanical systems like gyrocompasses and marine radars are critical for navigation and safe communication at sea. Advanced GPS technology and satellite communication systems also play a crucial role in maritime operations.

10. Ballast Systems: Ballast systems are used to control a ship's stability by adjusting the distribution of weight and buoyancy. Advanced ballast control systems enhance the safety and efficiency of vessels.

11. Marine Safety Equipment: Lifeboats, life rafts, and life-saving appliances are designed with mechanical systems to ensure they operate effectively during emergencies, such as ship evacuations.

12. Oceanographic Instruments: Mechanical instruments are used for collecting data in oceanography, including water sampling devices, deep-sea probes, and sediment corers.

13. Maintenance and Repair Technologies: Marine engineers use a variety of mechanical tools and technologies for maintenance and repair tasks, including welding equipment, underwater welding systems, and non-destructive testing methods.

14. Ship Automation: Automation technologies, including advanced control systems and robotics, are employed to optimize ship operations, reduce crew workload, and enhance safety.

15. Environmental Technologies: Mechanical technologies also address environmental concerns in the marine sector, with innovations in exhaust gas cleaning systems (scrubbers) and ballast water treatment systems to reduce pollution and prevent the spread of invasive species.

These mechanical technologies in the marine sector are essential for improving safety, efficiency, and environmental sustainability in maritime operations, whether for shipping, offshore energy production, scientific research, or underwater exploration.

ENGINEERING MATERIALS

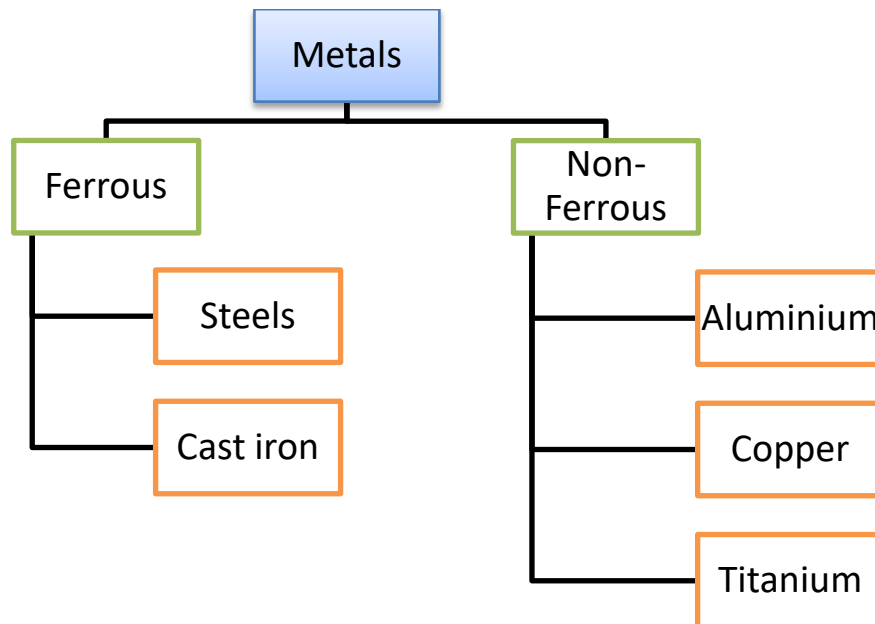
METALS – FERROUS & NON-FERROUS:

Definition: Metals are defined as those elements which possess lusture, are malleable and ductile and good conductors of heat and electricity. Metals are the elements which form positive ions by losing electrons i.e. they are electropositive elements. For e.g. sodium, magnesium, potassium, aluminium, copper, silver, gold etc.

Physical Properties:

Metals are malleable and ductile.

- Metals are good conductors of heat and electricity.
- Metals are lustrous (shiny) and can be polished.
- Metals are solids at room temperature (except mercury, which is liquid).
- Metals are tough and strong.



Applications: Metals are usually very strong, most durable and highly resistant to everyday wear and tear. As such, they have been used since ancient times for a lot of things. And even today with advances in technology and a lot of other things the uses of metals have broadened greatly. Metals even play a key role in the economy. Let's look at some important and popular metal uses.

- In the Construction Industry
- In electronics
- In medicine
- Machinery, Refractory and Automobiles
- Decorative products
- Other Uses

Differences between Ferrous & Non-Ferrous Metals:

	<u>Ferrous Metals</u>	<u>Non-Ferrous Metals</u>
1.	Contains any amount of iron in its basic form.	Does not contains any amount of iron in its basic form.
2.	That's why they possesses magnetic property and makes them prone to corrosion.	They do not possess magnetic property, but resist corrosion much better than ferrous metals.
3.	They have a high tensile strength since they can carry a high amount of strain.	They have very low tensile strength.
4.	They have the ability for oxidation, known as corrosion. Oxidation of ferrous metals forms as a reddish-brown deposit on the surface & is oxide of iron.	They have typically lighter weights, higher melting points & are basically resistant to corrosion.
5.	Typically used when the magnetic attraction of iron may be a disadvantage. (used where strength is the primary focal point)	Ideal for electronic & electrical applications.
6.	Eg., pig iron, steel, cast iron, etc.	Eg., cobalt, aluminium, zinc, etc.

CERAMICS:

Definition: A ceramic is a material that is neither metallic nor organic. It may be crystalline, glassy or both crystalline and glassy. Ceramics are typically hard and chemically non-reactive and can be formed or densified with heat.

Explanation:

Ceramics are classified as inorganic and nonmetallic materials that are essential to our daily lifestyle. Ceramic and materials engineers are the people who design the processes in which these products can be made, create new types of ceramic products, and find different uses for ceramic products in everyday life.

Ceramics are all around us. This category of materials includes things like tile, bricks, plates, glass, and toilets. Ceramics can be found in products like watches (quartz tuning forks-the time keeping devices in watches), snow skies (piezoelectric-ceramics that stress when a voltage is applied to them), automobiles (sparkplugs and ceramic engine parts found in racecars), and phone lines. They can also be found on space shuttles, appliances (enamel coatings), and airplanes (nose cones). Depending on their method of formation, ceramics can be dense or lightweight. Typically, they will demonstrate excellent strength and hardness properties; however, they are often brittle in nature. Ceramics can also be formed to serve as electrically

conductive materials, objects allowing electricity to pass through their mass, or insulators, materials preventing the flow of electricity. Some ceramics, like superconductors, also display magnetic properties.

Ceramics are generally made by taking mixtures of clay, earthen elements, powders, and water and shaping them into desired forms. Once the ceramic has been shaped, it is fired in a high temperature oven known as a kiln. Often, ceramics are covered in decorative, waterproof, paint-l

Ceramic Properties:

The properties of ceramic materials, like all materials, are dictated by the types of atoms present, the types of bonding between the atoms, and the way the atoms are packed together. This is known as the atomic scale structure. Most ceramics are made up of two or more elements. This is called a compound. For example, alumina (Al_2O_3), is a compound made up of aluminum atoms and oxygen atoms.

The atoms in ceramic materials are held together by a chemical bond. The two most common chemical bonds for ceramic materials are covalent and ionic. For metals, the chemical bond is called the metallic bond. The bonding of atoms together is much stronger in covalent and ionic bonding than in metallic. That is why, generally speaking, metals are ductile and ceramics are brittle. Due to ceramic materials wide range of properties, they are used for a multitude of applications. In general, most ceramics are:

- Hard,
- Wear-resistant,
- Brittle,
- Refractory,
- Thermal insulators,
- Electrical insulators,
- Nonmagnetic,
- Oxidation resistant,
- Prone to thermal shock, and
- Chemically stable.

Advantages:

- High Wear resistance and low coefficient of friction
- High Compressive strength
- High hardness and high temperature resistance.

Dis-Advantages:

- Brittle to heavy loads
- Less degree of flexibility in component fixation
- Unexpected fractures

Applications:

- Ceramics are more than pottery and dishes: clay, bricks, tiles, glass, and cement are probably the best-known examples.
- Ceramic materials are used in electronics because, depending on their composition, they may be semiconducting, superconducting, ferroelectric, or an insulator.
- Ceramics are also used to make objects as diverse as spark plugs, fiber optics, artificial joints, space shuttle tiles, cook tops, race car brakes, micro positioners, chemical sensors, self lubricating bearings, body armor, and skis.

COMPOSITES:

Definition: A composite material is made up of two or more materials with different chemical and physical properties. A composite material is used to enhance the properties of its base materials. Composites offer significant benefits in various material performance aspects, exceeding the mono-material alternatives and particularly standalone use of the constituent parts. Most man-made composites combine high tensile fibers that are flexible, with a matrix that forms the fibers into a rigid structure that acquires the compressive strength of the matrix material. The result is a combined material that benefits from the tensile strength of the fiber reinforcer, the compressive strength of the matrix, and the bending strength of their marriage to make a strong, rigid, stiff, and bend-tolerant resultant material.

Physical Properties:

Some common themes in the physical properties of composites can be generalized, including:

- The tensile strength of most composites approaches or exceeds that of the reinforcing material.
- The compressive strength is similar to or exceeds the compressive strength of the matrix material. This is despite the fact that the overwhelming bulk of most composites is a reinforcer and not a matrix.
- The bending strength generally greatly exceeds the tensile capacity of the matrix material, as the tensile loads of bending forces are transferred to the reinforcer component and dissipated without fracture.
- Electrical or thermal conductivity.
- Abrasion resistance.
- Reduced weight/density.
- Magnetic properties.
- Optical properties.
- Shock resilience.
- Fatigue and creep resistance.

Advantages:

1. A higher performance for a given weight leads to fuel savings. Excellent strength-to-weight and stiffness-to-weight ratios can be achieved by composite materials. This is usually expressed as strength divided by density and stiffness (modulus) divided by density. These are so-called "specific" strength and "specific" modulus characteristics.
2. Laminate patterns and ply buildup in a part can be tailored to give the required mechanical properties in various directions.
3. It is easier to achieve smooth aerodynamic profiles for drag reduction. Complex double-curvature parts with a smooth surface finish can be made in one manufacturing operation.
4. Part count is reduced.
5. Production cost is reduced. Composites may be made by a wide range of processes.
6. Composites offer excellent resistance to corrosion, chemical attack, and outdoor weathering; however, some chemicals are damaging to composites (e.g., paint stripper), and new types of paint and stripper are being developed to deal with this. Some thermoplastics are not very resistant to some solvents. Check the data sheets for each type.

Dis-Advantages:

1. Composites are more brittle than wrought metals and thus are more easily damaged. Cast metals also tend to be brittle.
2. Repair introduces new problems, for the following reasons:
 - Materials require refrigerated transport and storage and have limited shelf lives.
 - Hot curing is necessary in many cases, requiring special equipment.
 - Curing either hot or cold takes time. The job is not finished when the last rivet has been installed.
3. If rivets have been used and must be removed, this presents problems of removal without causing further damage.
4. Repair at the original cure temperature requires tooling and pressure.
5. Composites must be thoroughly cleaned of all contamination before repair.
6. Composites must be dried before repair because all resin matrices and some fibers absorb moisture.

Applications:

Composites are used in a wide variety of markets, including aerospace, architecture, automotive, energy, infrastructure, marine, military, and sports and recreation because of their exceptional properties.

- Aerospace
- Architecture
- Automotive
- Energy Production
- Energy storage
- Infrastructure
- Marine
- Pipe & Tank
- Sports & Recreation
- Transportation

SMART MATERIALS:

Definition: Smart materials are **materials that are manipulated to respond in a controllable and reversible way, modifying some of their properties as a result of external stimuli** such as certain mechanical stress or a certain temperature, among others. Because of their responsiveness, smart materials are also known as responsive materials. These are usually translated as "active" materials although it would be more accurate to say "reactive" materials.

For example, we can talk about **sportswear with ventilation valves that react to temperature and humidity by opening when the wearer breaks out in a sweat** and closing when the body cools down, about buildings that adapt to atmospheric conditions such as wind, heat or rain, or about drugs that are released into the bloodstream as soon as a viral infection is detected.

Types of Smart materials:

Nowadays, there are different types of smart materials and new ones arise every day. Among them, the following should be highlighted:

Piezoelectric materials: They can convert mechanical energy into electrical energy and vice versa. For example, they change their shape in response to an electrical impulse or produce an electrical charge in response to an applied mechanical stress.

Shape memory materials: They have the ability to change the shape, even returning to their original shape, when exposed to a heat source, among other stimuli.

Chromoactive materials: They change colour when subjected to a certain variation in temperature, light, pressure, etc. Nowadays, they are used in sectors such as optics, among others.

Magnetorheological materials: They change their properties when exposed to a magnetic field. For example, they are currently used in shock absorbers to prevent seismic vibrations in bridges or skyscrapers.

Photoactive materials: There are several types: electroluminescents emit light when they are fed with electrical impulses, fluorescents reflect light with greater intensity and phosphorescents are able to emit light after the initial source has ceased.

Physical Properties:

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.

Applications:

Materials science is a constant supply of news about new discoveries that could revolutionise our future. We review some of the most amazing materials from recent years below:

- **Synthetic spider web:** This material is not only five times stronger than steel, but also has great elasticity. Its potential uses include: bulletproof clothing, artificial skin for burns or waterproof adhesives.
- **Shrilk:** Its main component is chitin, a carbohydrate found in krill shells. It was created by researchers from Harvard University and is considered the ideal substitute for plastic — since its decomposition time is only two weeks and it also works as a stimulant for plant growth —.
- **Graphene:** Its potential uses are almost unlimited: batteries with more autonomy, cheaper photovoltaic solar cells faster computers, flexible electronic devices, more resistant buildings, bionic limbs, etc. All this is possible thanks to their multiple properties.
- **Metamaterials:** They are manufactured in the laboratory with unusual physical properties not found in nature and are the subject of research in fields such as the military, optics or telephony. They can, for example, bend electromagnetic waves of light creating negative refractive indices.
- **XPL:** It is a silicone-based polymer that adheres to the dermis like a second skin. Created by scientists at the Massachusetts Institute of Technology (MIT), it replicates the appearance of young, healthy skin by rejuvenating the look of the wearer.