RV College of Engineering®

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Unit I

2023-24 (Odd): 1st Semester

BE in CV, CY, EC, EI, IM

ME113AT: Fundamentals of Mechanical Engineering

(Category: Engineering Science)

(Theory)

ESC: 'C' Section

Unit – I

ENGINEERING MATERIALS

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Unit V

Engineering Materials >>

08 Hrs

- Introduction
- Classification
- Metals (Magnetic and Non-Magnetic), Materials
- Properties & Applications
  - Physical
  - Mechanical
  - Optical
  - Electrical and Electronics
  - Thermal
  - Chemical
- Applications
  - Aerospace
  - Automotive
  - Electronics and
  - Biomedical

Unit-I	8 Hrs
Engineering Materials: Introduction, Classification, Metals (Magnetic and Non-Magnetic), Materials. Properties & applications: physical, mechanical, optical, electrical and electronics, thermal, Chemical, Properties. Applications: Aerospace, Automotive, Electronic and Biomedical.	

Engineering Materials>>

- Introduction
- Classification
- Metals (Magnetic and Non-Magnetic)
- Materials

Unit-I	8 Hrs
Engineering Materials: Introduction, Classification, Metals (Magnetic and Non-Magnetic), Materials. Properties & applications: physical, mechanical, optical, electrical and electronics, thermal, Chemical, Properties. Applications: Aerospace, Automotive, Electronic and Biomedical.	

Engineering Materials>>

Introduction:

Extra Information.....

- Materials are so important in the development of human civilization that the historians have identified early periods of civilization by the name of most significantly used material, e.g.: Stone Age, Bronze Age.
- This is just an observation made to showcase the importance of materials and their impact on human civilization, It is obvious that materials have affected and controlling a broad range of human activities through thousands of decades.
- From the historical point of view, it can be said that human civilization started with Stone Age where people used only natural materials, like stone, clay, skin, and wood for the purposes like to make weapons, instruments, shelter, etc. Thus the sites of deposits for better quality stones became early colonies of human civilization.
- The increasing need for better quality tools brought forth exploration that led to Bronze Age, followed by Iron Age. When people found copper and how to make it harder by alloying.
- The use of iron and steel, a stronger material that gave advantage in wars . Iron was abundant and thus availability is not limited to the affluent. This commonness of the material affected every person in many aspects, gaining the name democratic material.
- The next big step in human civilization was the discovery of a cheap process to make steel which enabled the railroads and the building of the modern infrastructure of the industrial world. One of the most significant features of the democratic material is that number of users just exploded. Thus there has been a need for human and material resources for centuries, which still going strong.
- It’s being said and agreed that we are presently in Space Age marked by many technological developments towards development materials resulting in stronger and light materials like composites, electronic materials like semiconductors, materials for space voyage like high temperature ceramics, biomaterials, etc.

Engineering Materials>>
Introduction > Contd…

Extra Information…..

- All engineers need to know about materials. Even the most "immaterial", like software or system engineering depend on the development of new materials, which in turn alter the economics, like software-hardware trade-offs. Increasing applications of system engineering are in materials manufacturing (industrial engineering) and complex environmental systems.

- Innovation in engineering often means the clever use of a new material for a specific application. For example: plastic containers in place of age-old metallic containers. It is well learnt lesion that engineering disasters are frequently caused by the misuse of materials.

- It is vital that the professional engineer should know how to select materials which best fit the demands of the design - economic and aesthetic demands, as well as demands of strength and durability. Beforehand the designer must understand the properties of materials, and their limitations. Thus it is very important that every engineer must study and understand the concepts of Materials Science and Engineering. This enables the engineer:
  - To select a material for a given use based on considerations of cost and performance.
  - To understand the limits of materials and the change of their properties with use.
  - To be able to create a new material that will have some desirable properties.
  - To be able to use the material for different application.

Engineering Materials>> Classifications >

- Materials are classified in groups.
- One can classify them based on many criteria, for example crystal structure (arrangement of atoms and bonds between them), or properties, or use.
- The main classes of present engineering materials are Metals, Ceramics, Polymers, Composites, Semiconductors, and Biomaterials.

- **Metals:** These materials are characterized by high thermal and electrical conductivity; strong yet deformable under applied mechanical loads; opaque to light (shiny if polished). These characteristics are due to valence electrons that are detached from atoms, and spread in an *electron sea* that *glues* the ions together, i.e. atoms are bound together by metallic bonds and weaker van der Waalls forces. Pure metals are not good enough for many applications, especially structural applications. Thus metals are used in alloy form i.e. a metal mixed with another metal to improve the desired qualities. E.g.: aluminum, steel, brass, gold.
- **Ceramics:** These are inorganic compounds, and usually made either of oxides, carbides, nitrides, or silicates of metals. Ceramics are typically partly crystalline and partly amorphous. Atoms (ions often) in ceramic materials behave mostly like either positive or negative ions, and are bound by very strong Coulomb forces between them. These materials are characterized by very high strength under compression, low ductility; usually insulators to heat and electricity. Examples: glass, porcelain, many minerals.

Engineering Materials>>
Classifications > contd…

Extra Information…..

- **Polymers:** Polymers in the form of thermo-plastics (nylon, polyethylene, polyvinyl chloride, rubber, etc.) consist of molecules that have covalent bonding within each molecule and van der Waals forces between them. Polymers in the form of thermo-sets (e.g., epoxy, phenolics, etc.) consist of a network of covalent bonds. They are based on H, C and other non-metallic elements. Polymers are amorphous, except for a minority of thermoplastics. Due to the kind of bonding, polymers are typically electrical and thermal insulators. However, conducting polymers can be obtained by doping, and conducting polymer-matrix composites can be obtained by the use of conducting fillers. They decompose at moderate temperatures (100 – 400 C), and are lightweight. Other properties vary greatly.

- **Composite materials:** Composite materials are multiphase materials obtained by artificial combination of different materials to attain properties that the individual components cannot attain. An example is a lightweight brake disc obtained by embedding SiC particles in Al-alloy matrix. Another example is reinforced cement concrete, a structural composite obtained by combining cement (the matrix, i.e., the binder, obtained by a reaction known as hydration, between cement and water), sand (fine aggregate), gravel (coarse aggregate), and, thick steel fibers. However, there are some natural composites available in nature, for example – wood. In general, composites are classified according to their matrix materials. The main classes of composites are metal-matrix, polymer-matrix, and ceramic-matrix.

Engineering Materials>>
Classifications > contd…

Extra Information…..

- **Semiconductors:** Semiconductors are covalent in nature. Their atomic structure is characterized by the highest occupied energy band (the valence band, where the valence electrons reside energetically) full such that the energy gap between the top of the valence band and the bottom of the empty energy band (the conduction band) is small enough for some fraction of the valence electrons to be excited from the valence band to the conduction band by thermal, optical, or other forms of energy. Their electrical properties depend extremely strongly on minute proportions of contaminants. They are usually doped in order to enhance electrical conductivity. They are used in the form of single crystals without dislocations because grain boundaries and dislocations would degrade electrical behavior. They are opaque to visible light but transparent to the infrared. Examples: silicon (Si), germanium (Ge), and gallium arsenide (GaAs, a compound semiconductor).

- **Biomaterials:** These are any type material that can be used for replacement of damaged or diseased human body parts. Primary requirement of these materials is that they must be biocompatible with body tissues, and must not produce toxic substances. Other important material factors are: ability to support forces; low friction, wear, density, and cost; reproducibility. Typical applications involve heart valves, hip joints, dental implants, intraocular lenses. Examples: Stainless steel, Co-28Cr-6Mo, Ti-6Al-4V, ultra high molecular weight poly-ethelene, high purity dense Al-oxide, etc.

Engineering Materials>>
Classifications > contd…

Extra Information…..

Advanced Materials, Future Materials, and Modern Materials needs

- **Advanced Materials:** These are materials used in *High-Tech* devices those operate based on relatively intricate and sophisticated principles (e.g. computers, air/space-crafts, etc.). These materials are either traditional materials with enhanced properties or newly developed materials with high-performance capabilities. Hence these are relatively expensive. Typical applications: integrated circuits, lasers, LCDs, fiber optics, thermal protection for space shuttle, etc. Examples: Metallic foams, inter-metallic compounds, multi-component alloys, magnetic alloys, special ceramics and high temperature materials, etc.
- **Future Materials:** Group of new and state-of-the-art materials now being developed, and expected to have significant influence on present-day technologies, especially in the fields of medicine, manufacturing and defence. Smart/Intelligent material system consists some type of sensor (*detects an input*) and an actuator (*performs responsive and adaptive function*). Actuators may be called upon to change shape, position, natural frequency, mechanical characteristics in response to changes in temperature, electric/magnetic fields, moisture, pH, etc.

  Four types of materials used as actuators: Shape memory alloys, Piezo-electric ceramics, Magnetostrictive materials, Electro-/Magneto-rheological fluids.

  Materials / Devices used as sensors: Optical fibers, Piezo-electric materials, Micro-electro-mechanical systems (MEMS), etc

Engineering Materials>>
Classifications > contd…

Extra Information…..

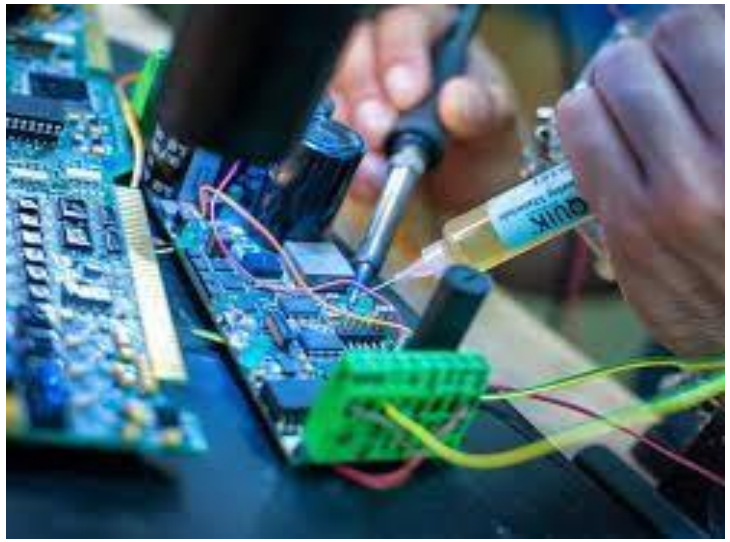
Typical applications: By incorporating sensors, actuators and chip processors into system, one can able stimulate biological human-like behavior; Fibers for bridges, buildings, and wood utility poles; They also help in fast moving and accurate robot parts, high speed helicopter rotor blades; Actuators that control chatter in precision machine tools; Small microelectronic circuits in machines ranging from computers to photolithography prints; Health monitoring detecting the success or failure of a product.

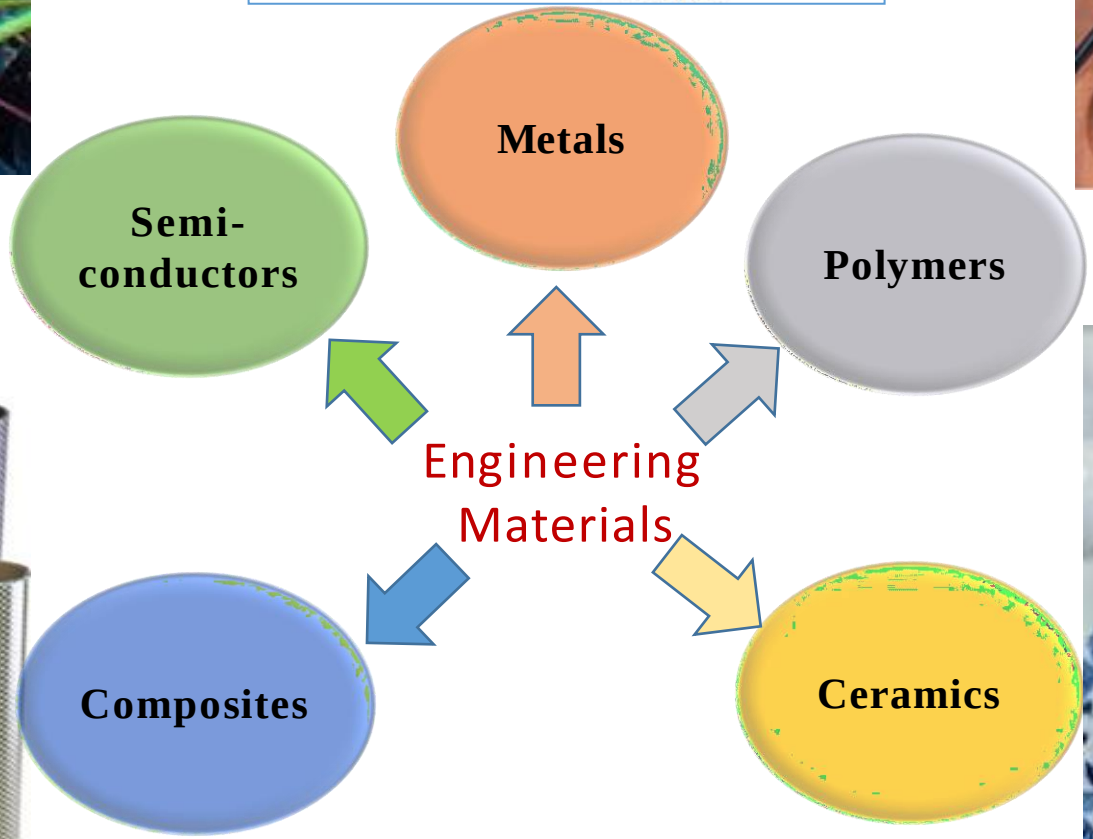
Modern Materials needs

- Though there has been tremendous progress over the decades in the field of materials science and engineering, innovation of new technologies, and need for better performances of existing technologies demands much more from the materials field. More over it is evident that new materials/technologies are needed to be environmental friendly. Some typical needs, thus, of modern materials needs are listed in the following:
  - ✓ Engine efficiency increases at high temperatures: requires high temperature structural materials
  - ✓ Use of nuclear energy requires solving problem with residues, or advances in nuclear waste processing.
  - ✓ Hypersonic flight requires materials that are light, strong and resist high temperatures.
  - ✓ Optical communications require optical fibers that absorb light negligibly.
  - ✓ Civil construction – materials for unbreakable windows.
  - ✓ Structures: materials that are strong like metals and resist corrosion like plastics.

Engineering Materials>>

Introduction:

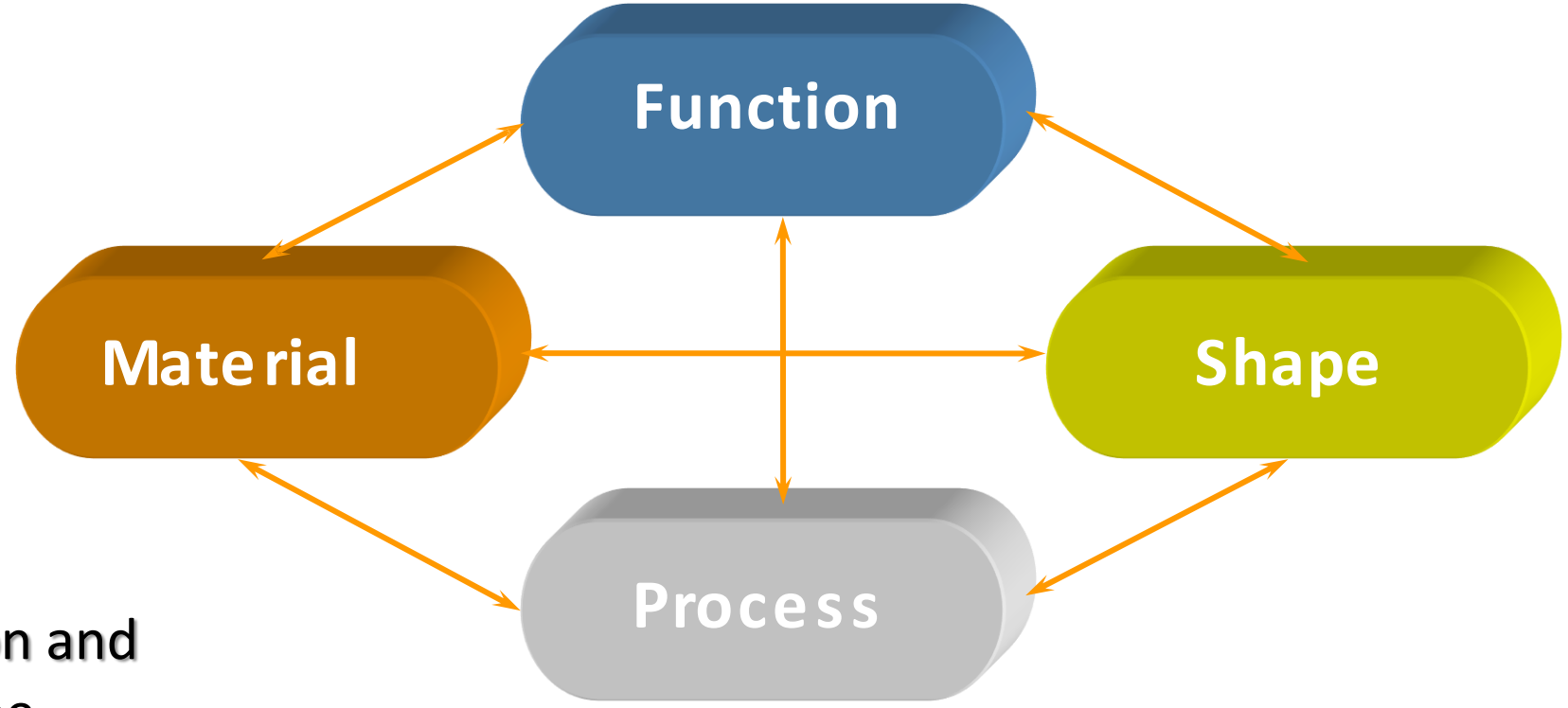




Engineering Materials>>

Material Selection:

Function
dictates the choice of material and shape



Material
Influences the Process

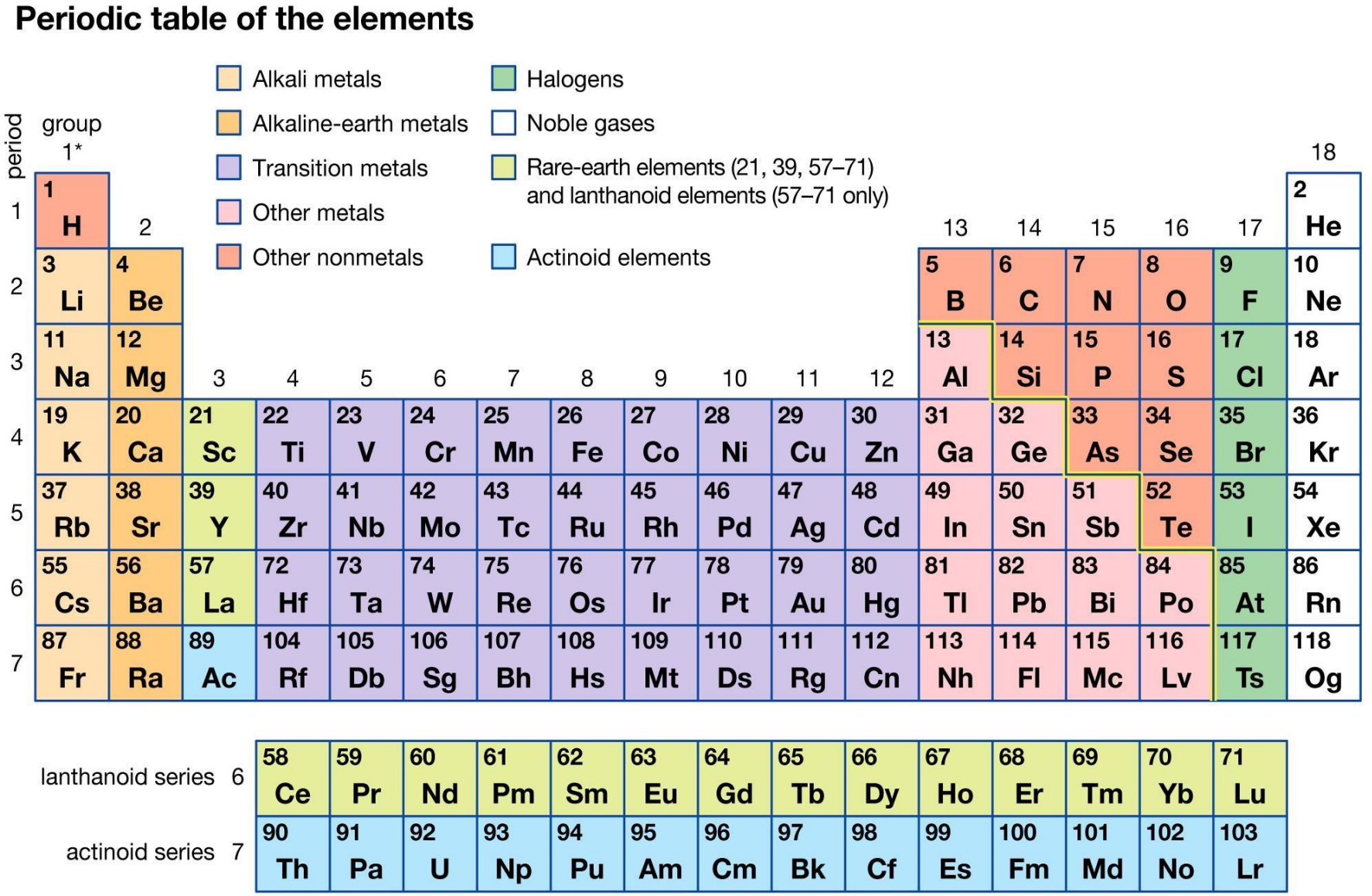
Shape
restricts the choice of material and process.

Process
interacts with shape

Material selection and process cannot be separated from the shape and the function of the product, two way interaction.

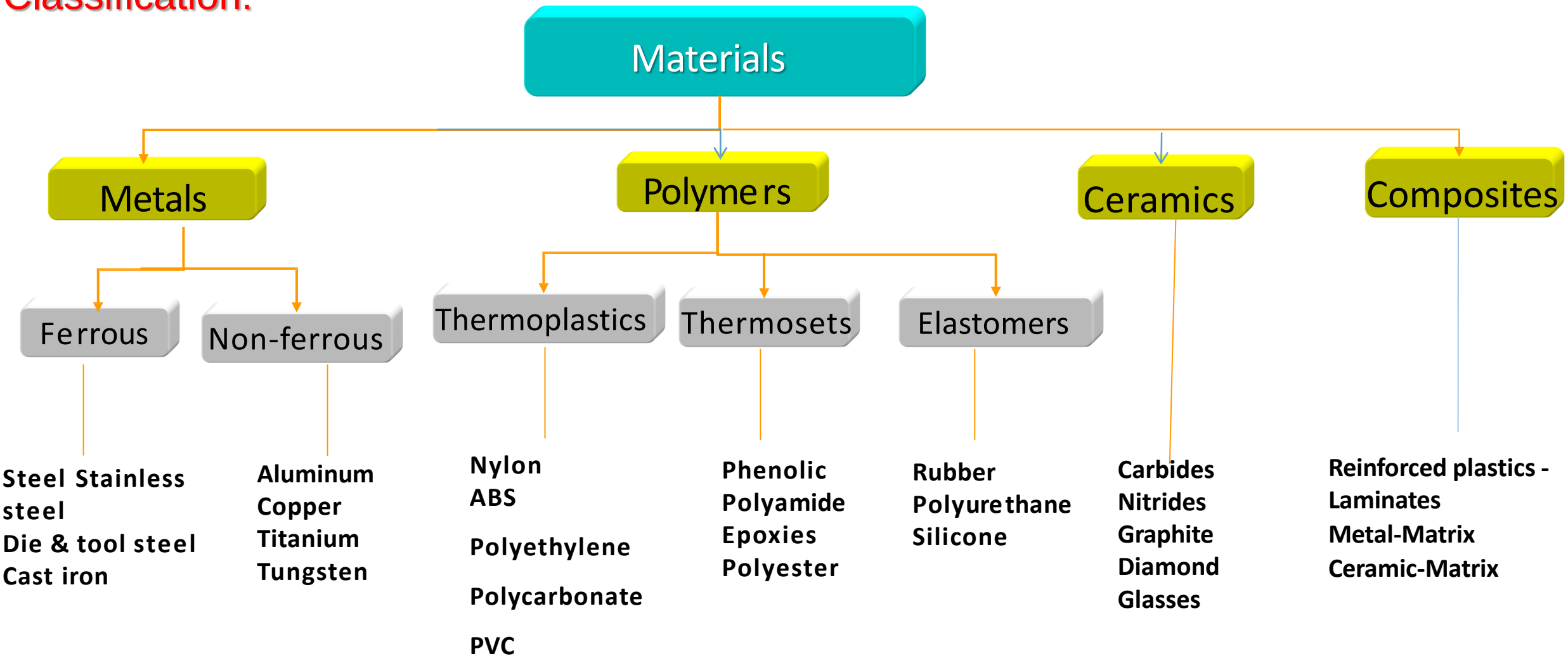
Engineering Materials>>

Periodic Table:



Engineering Materials>>

Classification:



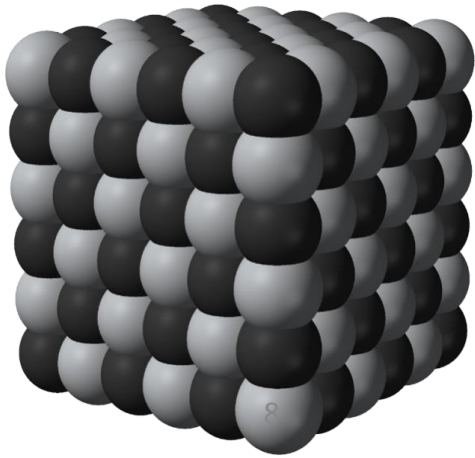
Engineering Materials>>

Metals >>

The atoms of metallic substances are closely positioned to neighbouring atoms in one of two common arrangements

A solid material which is typically

- hard,
- shiny,
- malleable,
- fusible, and
- ductile,
- with good electrical and
- thermal conductivity

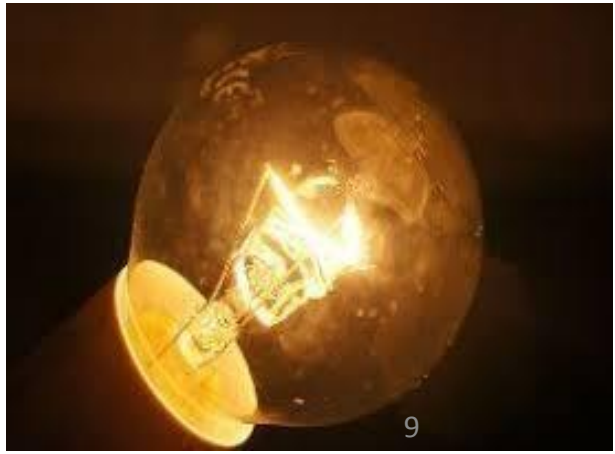


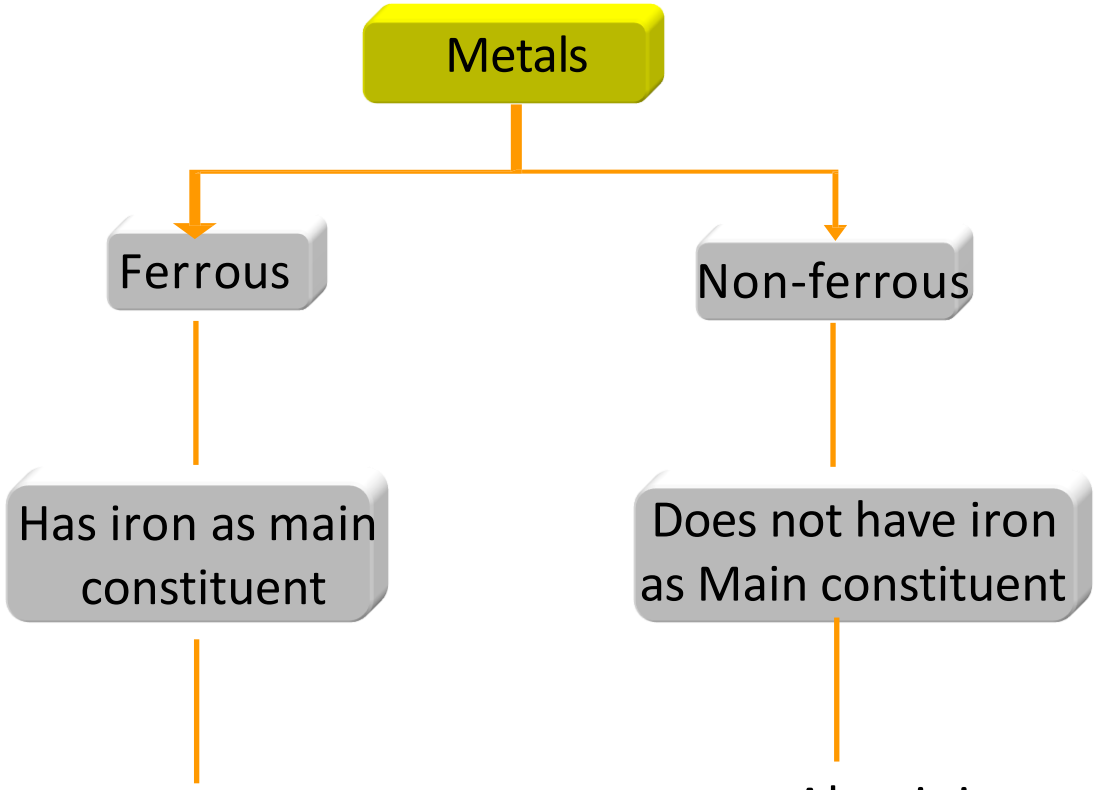
Examples:

Iron, Gold, Silver, and Aluminum, and Alloys such as steel

Engineering Materials>>

Metals > Classification>>





- Mild Steel
- Stainless steel
- Die & tool steel
- Cast iron

- Aluminium
- Copper
- Titanium
- Tungsten

Engineering Materials>>

Metals > Properties>>

- Strong
- Malleable and ductile
- React with oxygen to form basic oxides
- Sonorous
- High melting and boiling points
- Good conductors of electricity
- Good conductors of heat
- Mainly solids at room temperature, except mercury - liquid at room temperature.
- Shiny when polished
- Forms +ve, on forming ions
- High density

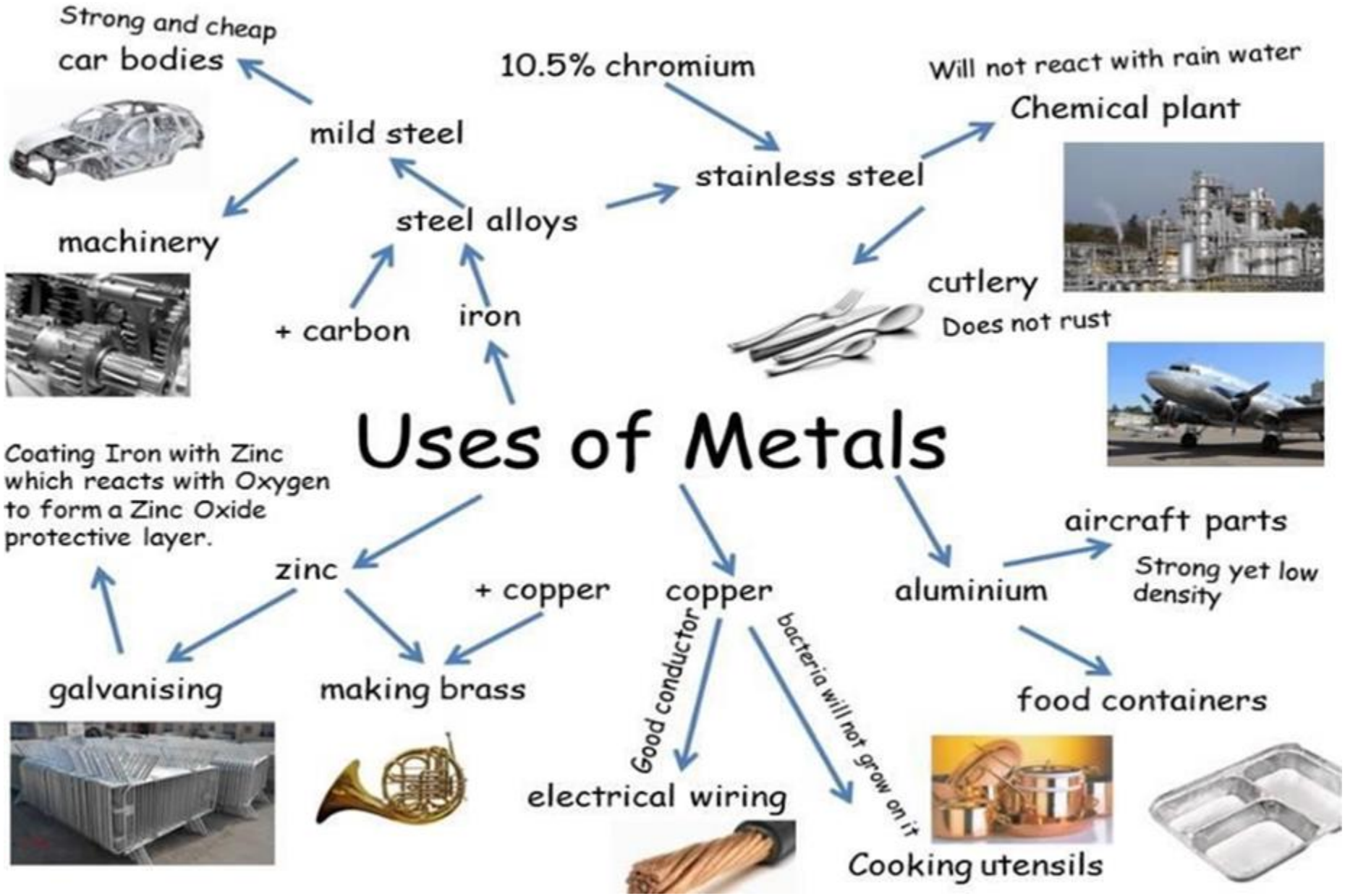
Engineering Materials>>

Metals > Uses / Application>>

- They are made into jewelry due to their hard and shiny appearance.
- They are used to make pans, since they are good conductors of heat.
- They are used in electrical cables, because they are malleable, ductile and good conductors of electricity.
- They are strong so used to build scaffolding and bridges.
- They make a ringing sound, sonorous, hence their use in bell making.

Engineering Materials>>

Metals > Uses / Application>>



Fundamentals of Mechanical Engineering

ENGINEERING MATERIALS

Assignment – Unit 1 - 01

<<for Practice>>

1) Explain with neat sketch ….
2) Brief about …..

Note:

i) Use new A4 size sheets, provide 1” left and top margin for each sheet.
ii) Write Roll No., Name (at right top), Topic and Assignment No. (at top Middle) in the 1st sheet.
iii) Use red pen to write the questions and blue or black pen for answer
iv) Draw neat sketches using instruments (avoid free hand sketching)

Polymers > Introduction >>

- A compound of high molecular weight derived either by the addition of any smaller molecules, as polyethylene, or by the condensation of many smaller molecules with the elimination of water, alcohol, or the like, as nylon.

- Natural polymers:
  - Amber,
  - wool,
  - silk and
  - natural rubber, etc.
- Synthetic polymers:
  - Synthetic rubber,
  - phenol formaldehyde resin (or Bakelite),
  - neoprene,
  - nylon,
  - polyvinyl chloride,
  - polystyrene, polyethylene, silicone, etc.

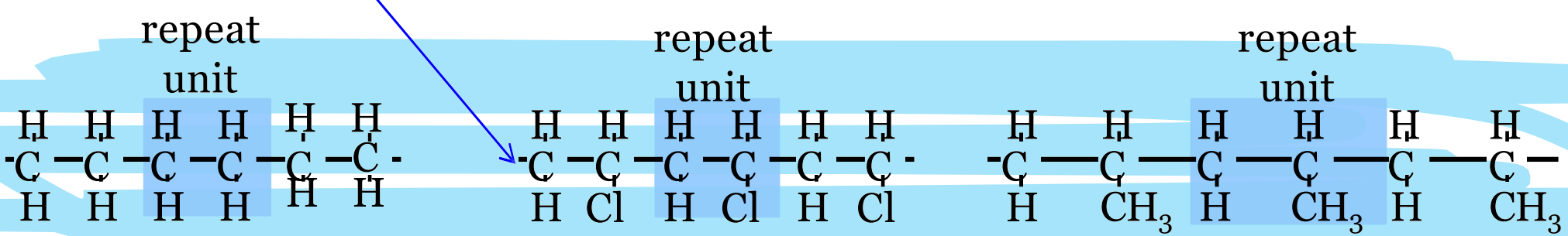
Polymers> Introduction >>

- A Polymer is a compound consisting of long-chain molecules, each molecule made up of repeating units connected together
- Each polymer molecule consists of thousands, even millions of units.
- The word polymer is derived from the Greek words poly, meaning many, and **meros** (reduced to mer), meaning **part**
- Most polymers are based on carbon and are therefore considered organic chemicals

Poly mer (meros)

=>many =>repeat unit (building blocks)

Carbon chain backbone



Polyethylene (PE) Polyvinyl chloride (PVC) Polypropylene (PP)

Engineering Materials>>

Polymers > Classification >>

- Polymers are classified as:
  - Plastics
  - Rubbers

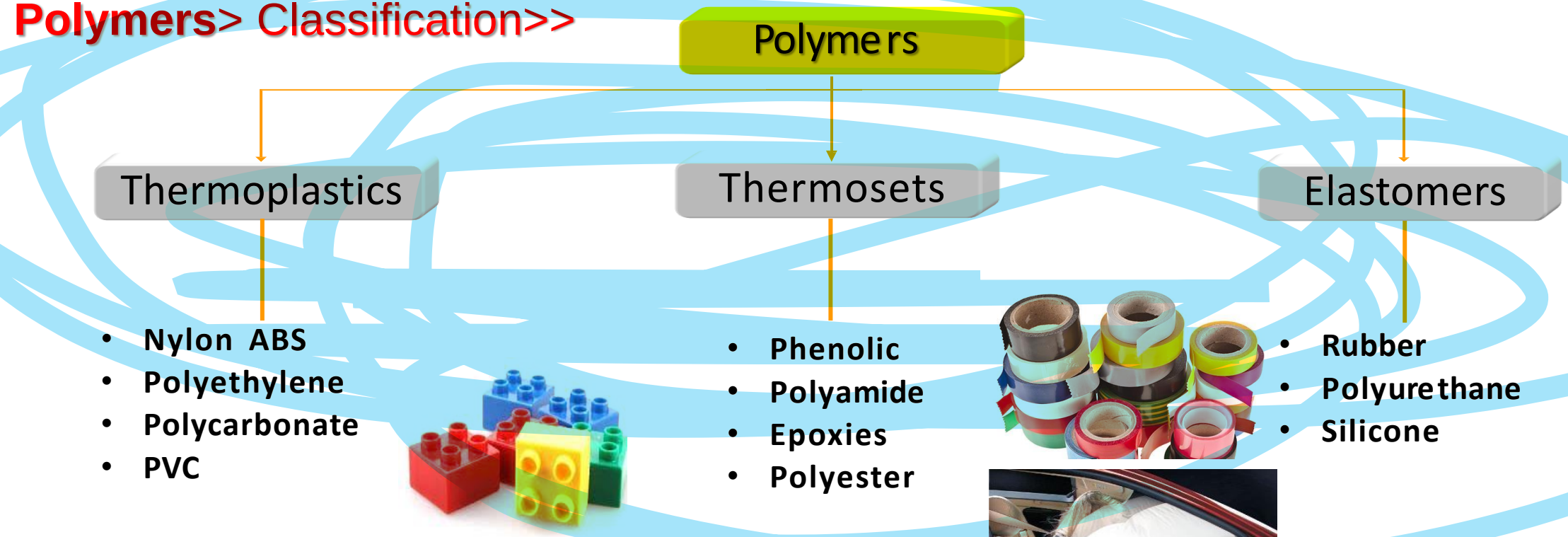
- Polymers can also be classified into three categories as mentioned below:
  - Thermoplastic polymers
  - Thermosetting polymers
  - Elastomers

Plastics

Rubbers

Engineering Materials>>

Polymers> Classification>>



Engineering Materials>>

Polymers> Characteristics>>

- Polymers have long chain structures. The individual molecule of a polymer is very large, i.e., it may consists of thousands of similar small molecules, all bonded together covalently
- Polymers have one thing common, i.e., carbon, which further bonds withhydrogen, nitrogen, halogens or other organic or inorganic substances
- Polymers are crystalline structure in simple materials but generally they are non-crystalline solids at room temperatures. And polymers pass through a viscous stage during formation.
- Polymers have light weight and they can be easily fabricated and shaped.
- Polymers are poor conductors of electricity and their thermal conductivity is also low.
- Polymers are resistant to chemical attack and decay

Engineering Materials>>

Polymers> Properties>>

Polymers are:

- Very resistant to chemicals.
- Both thermal and electrical insulators.
- Processed in various ways / methods.
- Can be used to make items that have no alternatives from other materials.
- Generally, polymers are very light in weight with significant degrees of strength.
- Are materials with a seemingly limitless range of characteristics and colors.
- Are usually made of petroleum, but not always.

Polymers> Thermosetting and Thermoplastics >>

Differences between Thermosetting and Thermoplastics

SN	Thermosetting Plastics	Thermoplastics
1	Three dimensional network of primary covalent bonds with cross linking between chains	Linear polymers without cross linking and branching
2	Upon heating they retain their strength and prolonged heating causes roasting of polymers and ultimately depolymerisation	Upon heating the secondary bonds between individual chains break, the polymers become soft and on cooling hard and rigid because secondary bonds re-establish themselves
3	Harder, stronger and more brittle	Strong and less brittle
5	It is difficult to fill an intricate mold with such plastics	They can fill the complicated mold quite easily
6	They can not be recycled	They can be recycled
7	Ex: Polyesters, Silicones, Bakelite , etc.	Ex: PVC, Nylons, polyethylene
8	Applications: manufacture of telephones, electrical outlets, appliance handles etc.	Applications: Plastic walls, floor tiles, reflectors, plastic lenses etc.

Engineering Materials>>

Polymers> Elastomers>>

- Polymers capable of large elastic deformation when subjected to relatively low stresses.
- Some can be extended 500% or more and still return to their original shape.
- Elastomers can be classified into following two categories:
  - Natural rubber - derived from biological plants
  - Synthetic polymers - produced by polymerization
- processes similar to those used for thermoplastic and thermosetting polymers

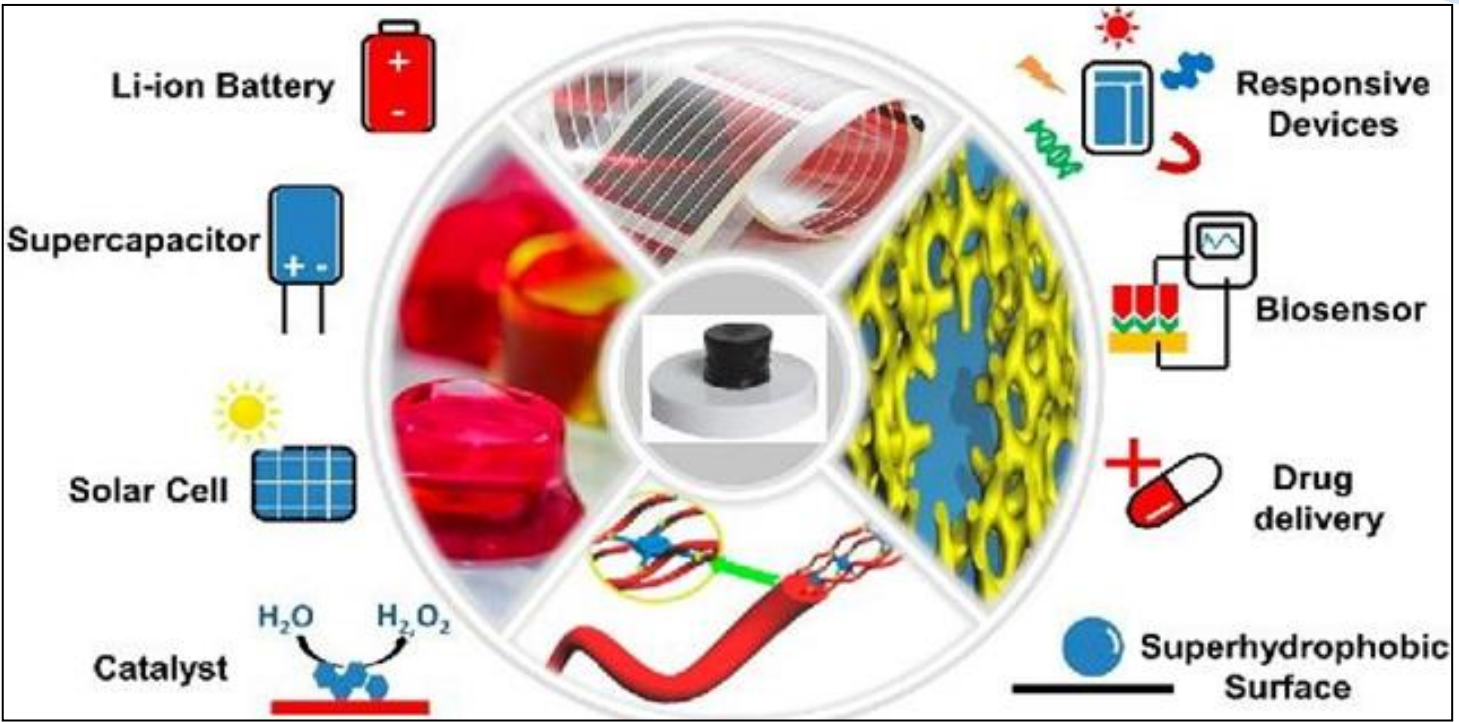
Characteristics of Elastomers

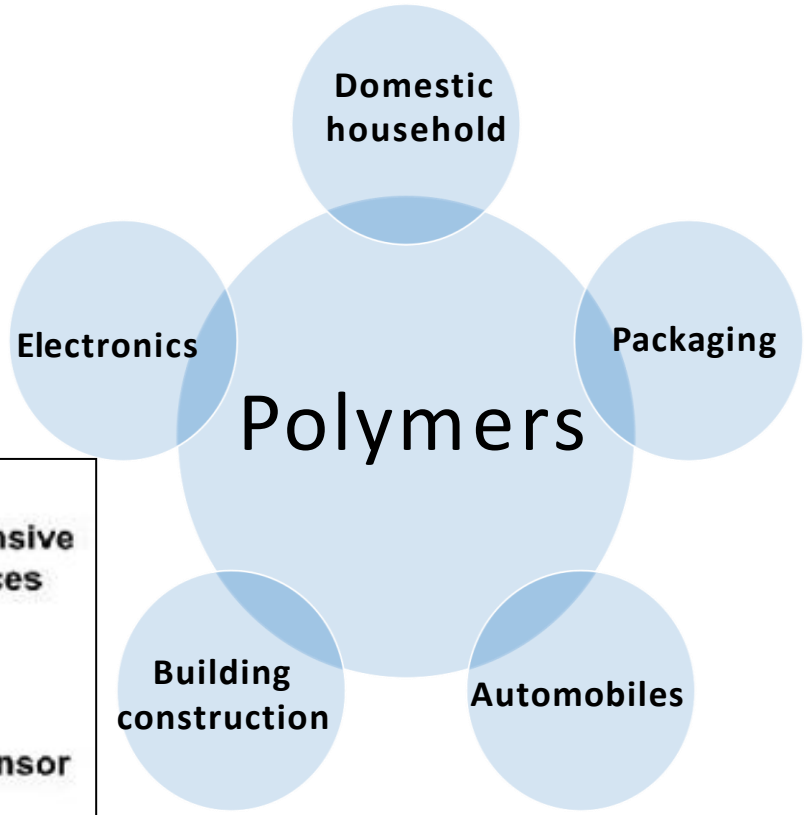
- Elastomers consist of long-chain molecules that are cross-linked (like thermosetting polymers)
- They owe their impressive elastic properties to two features:
  - Molecules are tightly linked when unstretched
  - Degree of cross-linking is substantially less than Thermosets

Engineering Materials>>

Polymers> Applications>>

- While plastics are used as a common example of polymers, there are many other materials which are also polymers.
- Proteins, such as hair, nails, tortoise shell
- Cellulose in paper and trees
- DNA
- Rubber





Engineering Materials>>

Polymers> Applications> Composites>>

Engineering Materials>>

Polymers > Applications > Biomedical>>

Engineering Materials>>

Ceramics> Introduction>>

- Ceramic materials are inorganic, non-metallic materials made from compounds of a metal and a non metal. They are formed by the action of heat and subsequent cooling.
- Ceramics can be classified into following two types :
  - Crystalline
  - Non-crystalline-glass
- Some ceramics are semiconductors. Most of these are transition metal oxides that are II-VI semiconductors such as zinc oxide.
- Some ceramics exhibit high temperature superconductivity under certain conditions such as extremely low temperature.

Applications:

- They are used in automotive engines, aerospace technology, electronics for insulator components, and in bio-medical replacements for bones and teeth.
- Other applications include construction materials and cutting tools

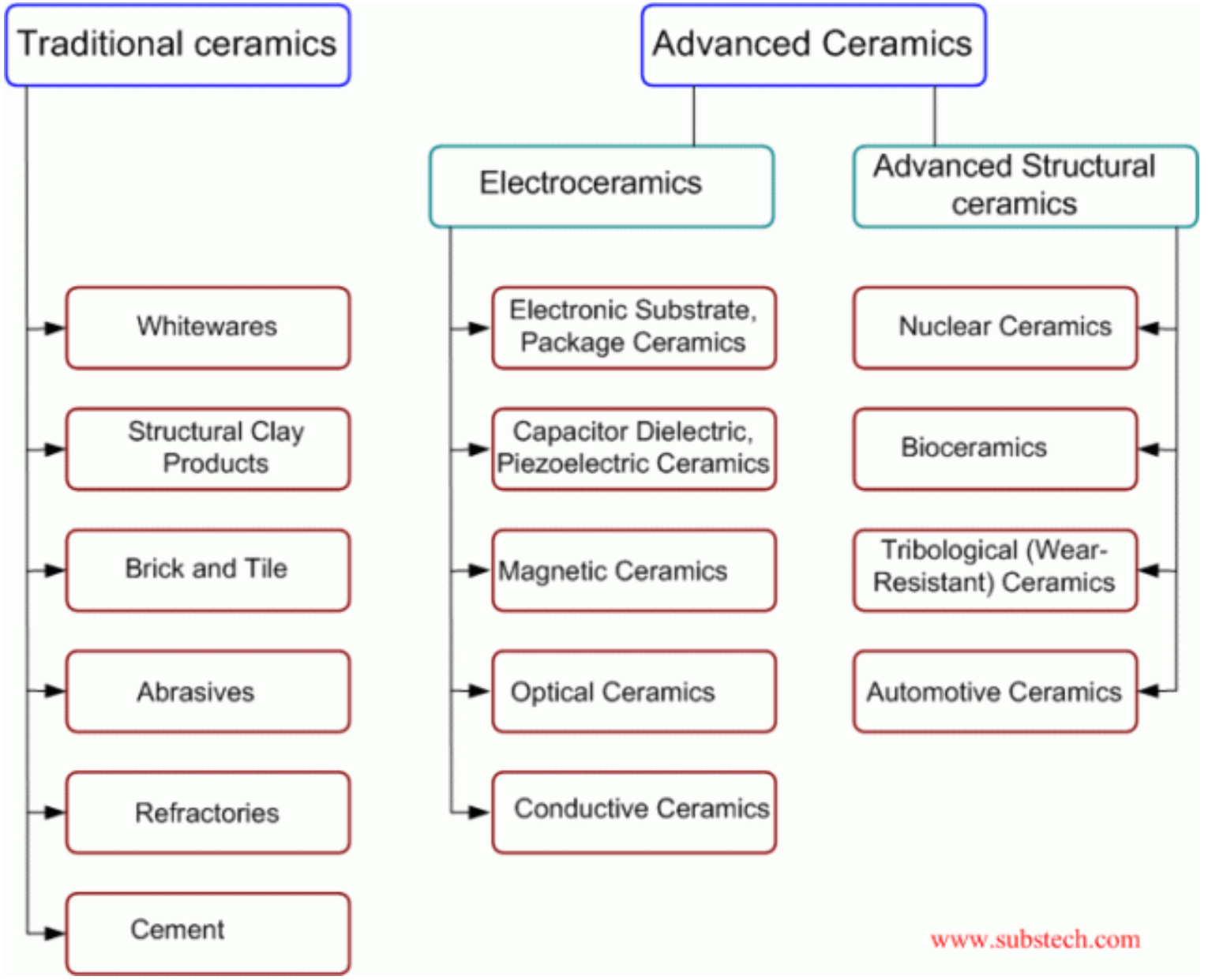
Ceramics> Properties>>

- Hard and Brittle
- Wear-resistant
- Refractory
- Thermal and Electrical Insulators
- Nonmagnetic
- Oxidation Resistant
- Prone To Thermal Shock
- Chemically Stable

Engineering Materials>>

Ceramics> Classification>>

General Classification



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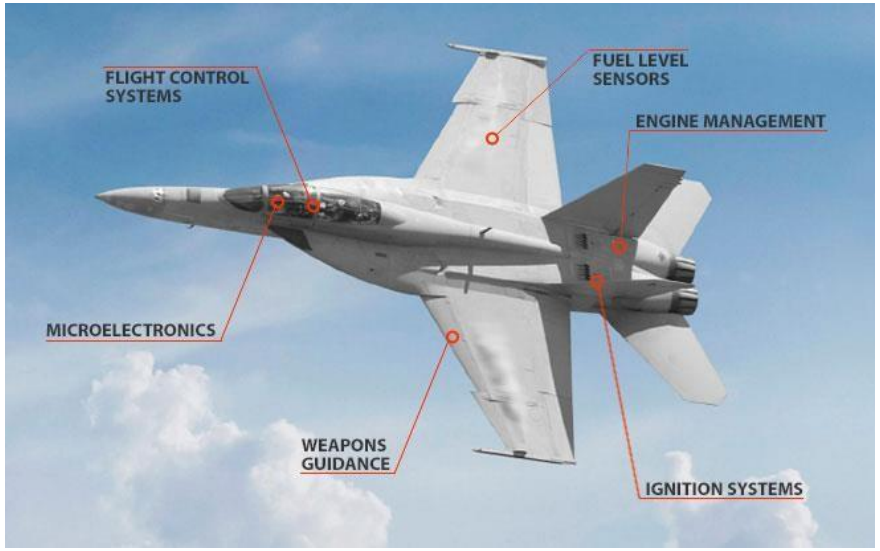
Engineering Materials>>

Ceramics> Applications>>

Ceramics in engineering are utilised for their heat, wear, and electrical resistance.

- Aerospace: space shuttle tiles, thermal barriers, high temperature glass windows, fuel cells
- Automotive: catalytic converters, ceramic filters, airbag sensors, ceramic rotors, valves, spark plugs,
- Communications: fiber optic/laser communications, TV and radio components, microphones
- Computers: insulators, resistors, superconductors, capacitors, ferroelectric components, microelectronic packaging
- Medical (Bio ceramics): orthopedic joint replacement, prosthesis, dental restoration, bone implants
- Military: structural components for ground, air and naval vehicles, missiles, sensors
- Consumer Uses: glassware, windows, pottery, Corning¨ ware, magnets, dinnerware, ceramic tiles, lenses, home electronics, microwave transducers
- Other Industries: bricks, cement, membranes and filters, lab equipment



Engineering Materials>>

Ceramics>

Classification>>

Based on applications

APPLICATION	TYPES	PROPERTIES	EXAMPLES
Glasses	Containers, windows, mirrors, lenses	Non-crystalline silicates, influenced by oxides such as CaO, Na2O, K2O, and Al2O3, unique response to heating	Bottles, camera lenses, smartphone screens
Clay Products	Structural products (bricks, tiles, sewer pipes), whitewares (porcelain, chinaware, pottery)	Made from abundant clay material, ease of production	Roof tiles, dinnerware, bathroom fixtures
Refractories	High temperature resistance, inertness in severe environments, thermal insulation	Capable of withstanding extreme temperatures without melting or decomposing	Kiln linings, furnace walls, space shuttle heat shields
Abrasive Ceramics	Hardness, wear resistance, toughness, refractoriness	Used for grinding, cutting, or wearing away other materials	Grinding wheels, sandpaper, cutting tools
Cement	Form a slurry that sets and hardens when mixed with water, can be used as bonding phases	Virtually any shape can be formed when mixed with water	Concrete, plaster of paris, mortar
Advanced Ceramics	Newly developed and manufactured for specific applications exploiting electrical, magnetic, and optical properties	Electrical, magnetic, and/or optical properties capable of being fine-tuned for specific applications	Heat engines, ceramic armors, electronic packaging

Additional Information....

ACM
ADVANCED CERAMIC MATERIALS
23661 Birtcher Dr. Lake Forest, CA 92630 U.S.A.
Tel: (949) 407-8904
Email: sales@preciseceramic.com

Engineering Materials>>

Ceramics> Applications>>

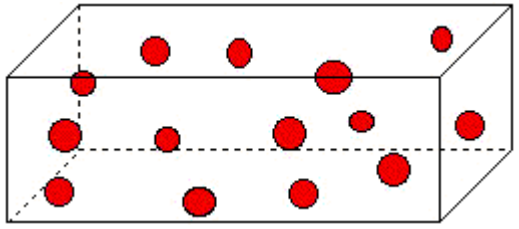
Additional Information....

Engineering Materials>>

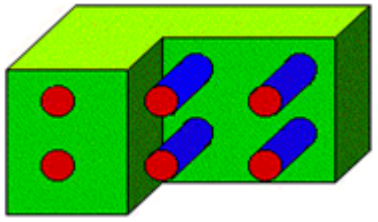
Composites> Introduction>>

- **Composite materials** are materials made from two or more constituent materials with significantly different physical or chemical properties, that when combined, produce a material with characteristics different from the individual components.
- **Typical classification:**
  - **Particulate composite:** materials contain a large number of randomly oriented particles.
  - Examples: ceramic particles dispersed in a metallic matrix
  - **Fibre-reinforced composites:** These are composed of strong and stiff brittle fibers which are incorporated into matrix.
  - **Laminated Composites:** These are Composed of layers of different materials, called laminates
- **Typical engineered** composite materials include:
  - Composite building materials such as cements, concrete
  - Reinforced plastics such as fibre-reinforced polymers
  - Metal Composites

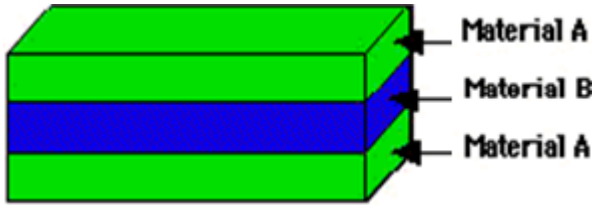
Particulate composite



Fibre-reinforced composite



Laminated composite



Engineering Materials>>

Composites> Classification>>

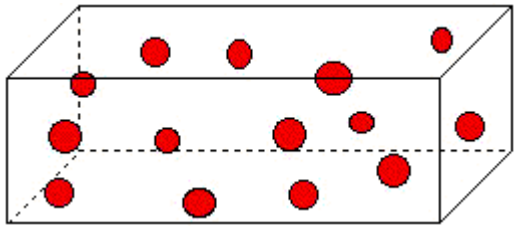
- Composites
  - Particle-reinforced
    - Large-particle
    - Dispersion-strengthened
  - Fiber-reinforced
    - Continuous (aligned)
    - Discontinuous (short)
      - Aligned
      - Randomly oriented
  - Structural
    - Laminates
    - Sandwich panels

face sheet
adhesive layer
honeycomb

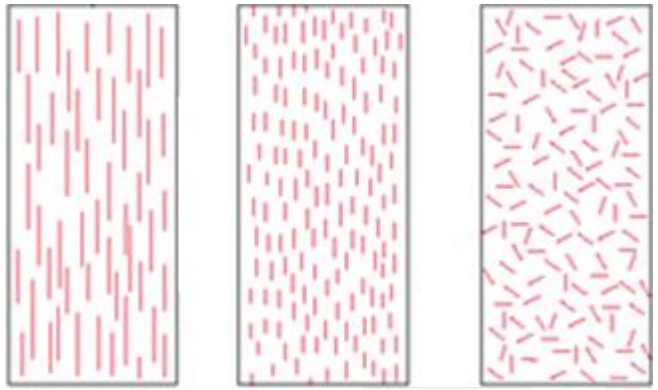
- Sandwich panels

> Low density, honeycomb core

> Benefit: light weight, large bending stiffness



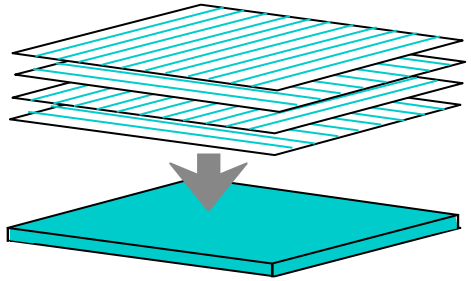
Particulate composite

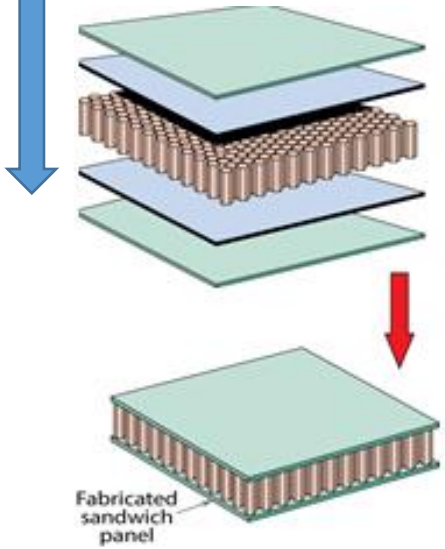


Aligned Continuous

Discontinuous

Random





Composites> Properties>>

- High Strength to Weight Ratio: Fibre composites are extremely strong for their weight
- Fire Resistance
- Chemical & Weathering Resistance: Composite products have good weathering properties and resist the attack of a wide range of chemicals.
- Translucency: Polyester resins are widely used to manufacture translucent mouldings and sheets.
- Manufacturing Economy: due to their easy of production composite materials are economically easy to produce

Composites> Applications>>

- Light weight and strong - buildings, bridges and structures such as boat hulls,
- Carbon composite is a key material in today's launch vehicles and heat shields for the re-entry phase of spacecraft race car bodies,
- Used in storage tanks, imitation granite and cultured marble sinks and counter tops.
- Wood is a naturally occurring composite comprising cellulose fibers in a lignin and hemicellulose matrix
- Applications:
  - Aerospace industry
  - Sporting Goods Industry
  - Automotive Industry
  - Home Appliance Industry

Engineering Materials>>

Composites> Applications>>

➢ FRPs – Fibre Reinforced Plastics

- Pipes, roofing's, storage containers, industrial floorings and automotive bodies
- Sports and recreational equipment's, pressure vessels and aircraft structural components.
- Military aircraft components, helicopter rotor blades and in some sporting goods.
- Sic and Al2O3 fibre reinforced composites are used in tennis rackets, circuit boards and rocket cone noses.

➢ CMCs – Ceramic Matrix Composites

- Concrete which contains steel rods in a matrix of cement , sand and crushed stones is extensively used in construction applications.
- Sic particles reinforced in Titanium –di –boride matrix has good wear and corrosion resistance and hence can be used to produce heat exchangers.

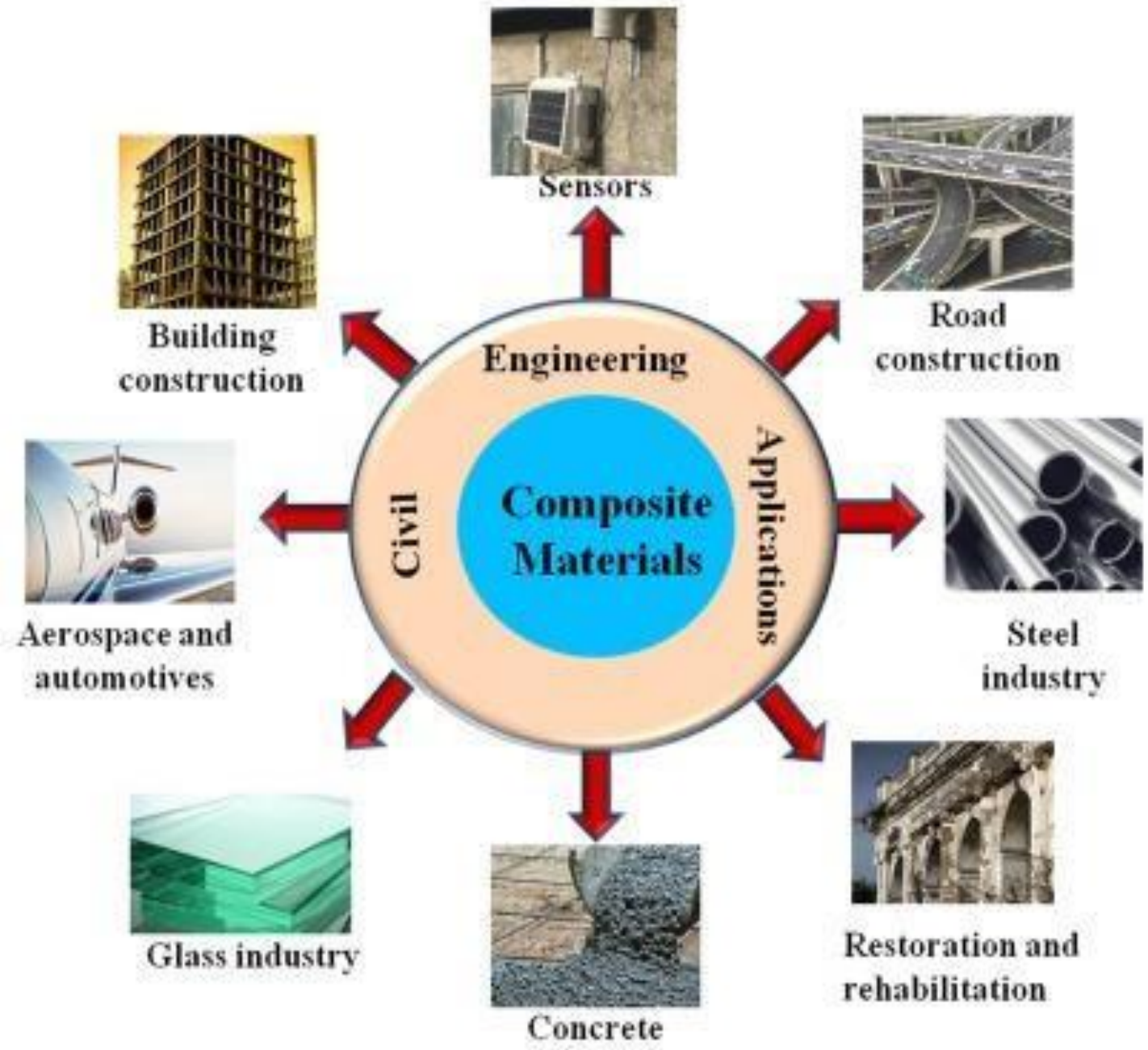
➢ MMCs – Metal matrix Composites

- Boron fibre reinforced aluminium alloy matrix composites are used as structural members in space shuttles owing to its strength to weight ratio.
- Al2O3 reinforced aluminium matrix finds applications in producing sporting equipment's and automobile engine parts.

Engineering Materials>>

Composites> Applications>>

- Engineering and Domestic Applications:
  - Aerospace industry
  - Sporting Goods Industry
  - Automotive Industry
  - Home Appliance Industry



Fundamentals of Mechanical Engineering

ENGINEERING MATERIALS

Assignment – Unit 1 - 02

<<for Practice>>

1) Explain with neat sketch ….
2) Brief about …..

Note:

i) Use new A4 size sheets, provide 1” left and top margin for each sheet.
ii) Write Roll No., Name (at right top), Topic and Assignment No. (at top Middle) in the 1st sheet.
iii) Use red pen to write the questions and blue or black pen for answer
iv) Draw neat sketches using instruments (avoid free hand sketching)

Engineering Materials>>

Material Properties>>

- **Physical Properties:**
  Solubility, Melting and Boiling point, Density, Color and luster, Odor, State, Texture, Viscosity
- **Chemical properties:**
  Corrosion Resistance, Combustibility, Toxicity, Reactivity
- **Mechanical properties:**
  Stress / strain curve for mild steel covering terminologies, hardness, brittleness, ductility, malleability.
- **Thermal properties:**
  Heat capacity, Coefficient of thermal expansion, thermal conductivity
- **Electrical and electronics properties:**
  Resistivity, conductivity, dielectric strength, semiconductors
- **Optical properties:**
  Reflection, Refraction, Absorption

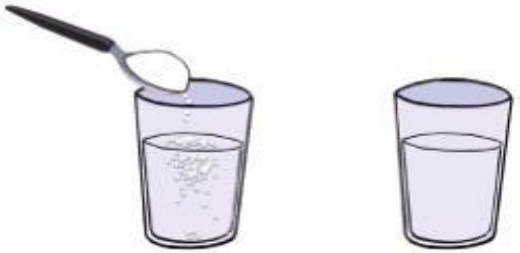
Engineering Materials>>

Physical Properties>>

- **Physical property** is a property that can be easily observed without changing the identity of the substance.
- It can be **reversible** or **irreversible**
- Substance may seem different, but the way the atoms link up is the same.
  - Solubility
  - Freezing point
  - Melting point
  - Boiling point
  - Density
  - Color and luster
  - Odor
  - State
  - Texture
  - Viscosity

Engineering Materials>>

Physical Properties contd..>>



Solubility of a substance is its ability to dissolve
Example: Sugar in water

Melting Point is the temperature at which a solid becomes liquid
Example: Ice becoming water

Freezing Point is the temperature at which a liquid becomes solid
Example: Water becoming ice

Density of a substance is a measure of how close together its particles are.

Engineering Materials>>

Chemical Properties>>

Chemical property is the ability of a material to produce a change in the identity of matter.

Chemical changes occur when a substance reacts and forms one or more new substances.

Examples:

- Corrosion Resistance
- Combustibility
- Toxicity
- Reactivity

The following indicate that a chemical change has occurred:

- ✓ Change in color or odor
- ✓ Production of a gas (bubbling)
- ✓ Formation of a precipitate (solid)
- ✓ Absorb or release energy (gets hot or cold or light is given off)

Engineering Materials>>

Chemical Properties contd..>>

- **Corrosion resistance** can be defined as the ability to protect the substrate from corrosion. In this case coating microstructure, in particular the appearance of open porosity and cracks, can be more important than the coating composition.

- **Combustibility** is a measure of how easily a substance bursts into flame, through fire or combustion.
  This is an important property to consider when a substance is used for construction or is being stored. It is also important in processes that produce combustible substances as a by-product.

- **Toxicity** is the degree to which a substance (a toxin or poison) can harm humans or animals. Acute toxicity involves harmful effects in an organism through a single or short-term exposure.

- **Reactivity** then refers to the rate at which a chemical substance tends to undergo a chemical reaction in time. In pure compounds, reactivity is regulated by the physical properties of the sample. For instance, grinding a sample to a higher specific surface area increases its reactivity

Engineering Materials>>

Chemical Properties contd..>>

Examples of Chemical Changes:

Burning Or Combustion:
Color change, odor change, Produces a gas, gets hot

Rusting or Corroding:
Color change

Decaying:
Color change

Molding:
Color change

Digesting:
Color change, odor Change, releases energy

Fundamentals of Mechanical Engineering

ENGINEERING MATERIALS

Assignment – Unit 1 - 03

<<for Practice>>

1) Explain with neat sketch ….
2) Brief about …..

Note:

i) Use new A4 size sheets, provide 1” left and top margin for each sheet.
ii) Write Roll No., Name (at right top), Topic and Assignment No. (at top Middle) in the 1st sheet.
iii) Use red pen to write the questions and blue or black pen for answer
iv) Draw neat sketches using instruments (avoid free hand sketching)

Engineering Materials>>

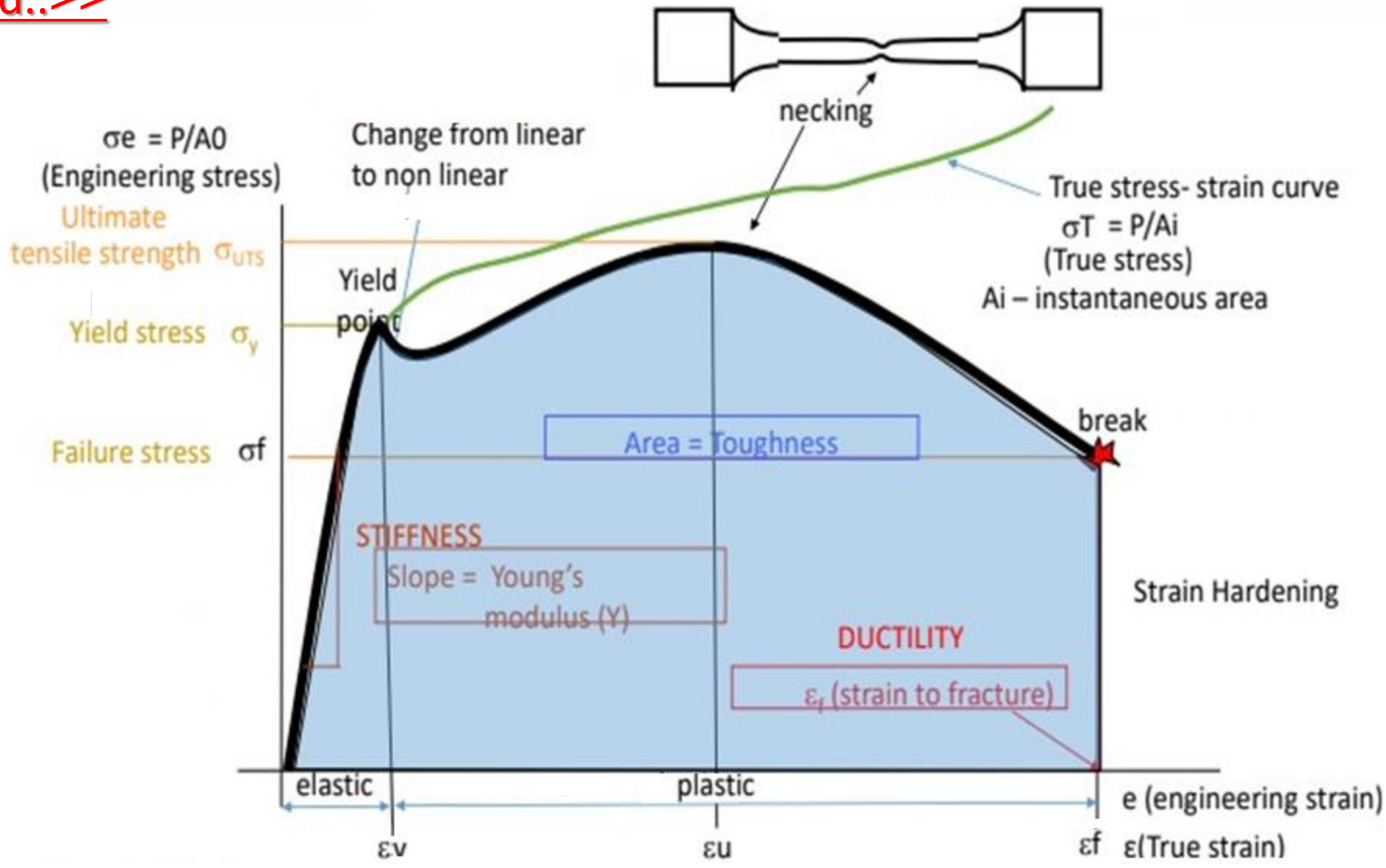
Mechanical Properties>>

- The mechanical properties of a material are used to determine its suitability for a particular application.
- It is convenient to break the properties, and the tests that measure them, into several types.
- General properties of materials :
  - **Hardness:** It is defined as the resistance material to penetration
  - **Brittleness:** It is defined as failure of material at shock loads
  - **Ductility:** It is defined as the ability of material to drawn out into wires
  - **Malleability:** It is defined as the property of material to form into sheets

Engineering Materials>>

Mechanical Properties contd..>>

- ✓ **Modulus of elasticity:** The initial slope of the curve, related directly to the strength of the atomic bonds.
- ✓ **Yield strength:** The point at which a consistent and measurable amount of permanent strain remains in the specimen.
- ✓ **Ductility:** The total elongation of the specimen due to plastic deformation, neglecting the elastic stretching
- ✓ **Toughness:** The total area under the curve which measures the energy absorbed by the specimen in the process of breaking

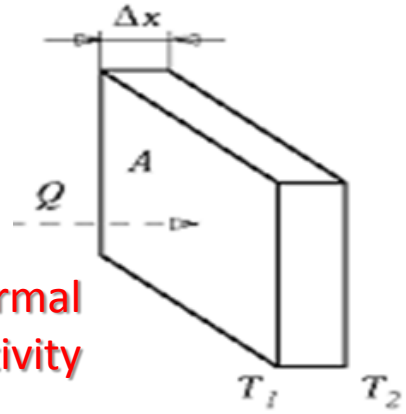


Engineering Stress-Strain Curve
of a typical ductile material (eg. Mild Steel)

Engineering Materials>>

Thermal Properties>>

- Specific heat
- Coefficient of Thermal Expansion (CTE)
- Thermal Conductivity



Thermal Conductivity

➢ **Specific heat** is defined as the amount of heat per unit mass required to raise the temperature by one degree Celsius. And it is represented as '**c**'

- The relationship between heat and temperature change is usually expressed as: $C = \frac{Q}{m \times \Delta T}$

➢ **Coefficient of Thermal Expansion (CTE)** is defined as the fractional increase in the length per unit rise in temperature. It is represented as 'α'

$$\alpha_V = \frac{1}{V}\left(\frac{\partial V}{\partial T}\right)$$

➢ **Thermal Conductivity** is defined as the rate at which heat passes through a specified material.

- It is expressed as the amount of heat that flows per unit time through a unit area with a temperature gradient of one degree per unit distance.
- The opposite face is maintained at a temperature difference of 1 degree

$$k = \frac{Q\Delta x}{A(T_2 - T_1)}$$

Electrical and Electronic Properties>>

- **Ohms Law :** Ohm's law states that the current through a conductor between two points is directly proportional to the potential difference across the two points. Introducing the constant of proportionality, the resistance.
- **Resistivity :** a measure of the resisting power of a specified material to the flow of an electric current.

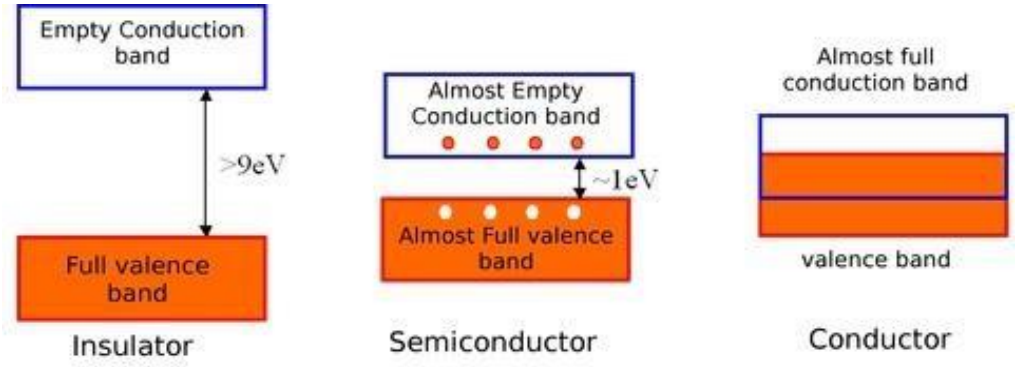
$$\rho = R\frac{A}{l}$$

- **Conductivity:** The degree to which a specified material conducts electricity, calculated as the ratio of the current density in the material to the electric field which causes the flow of current.

$$\sigma = \frac{1}{\rho}$$

- **Dielectric strength :** Of an insulating material, the maximum electric field that a pure material can withstand under ideal conditions without breaking down (i.e., without experiencing failure of its insulating properties).

- Insulators
- Semiconductors
- Conductors

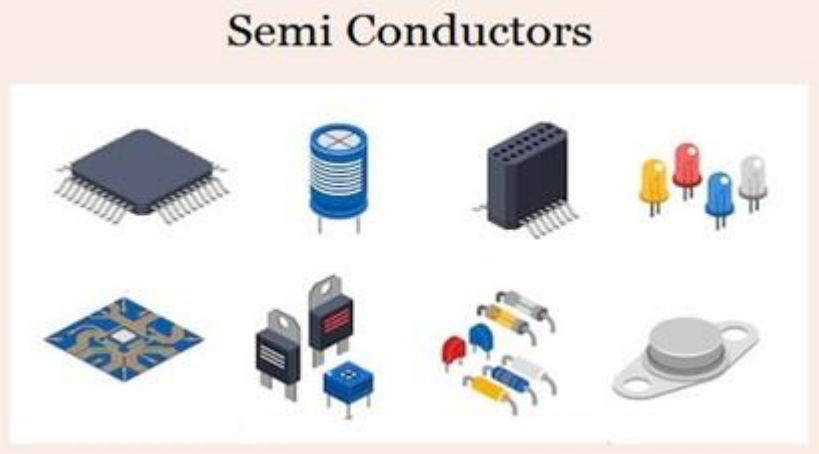


Engineering Materials>>

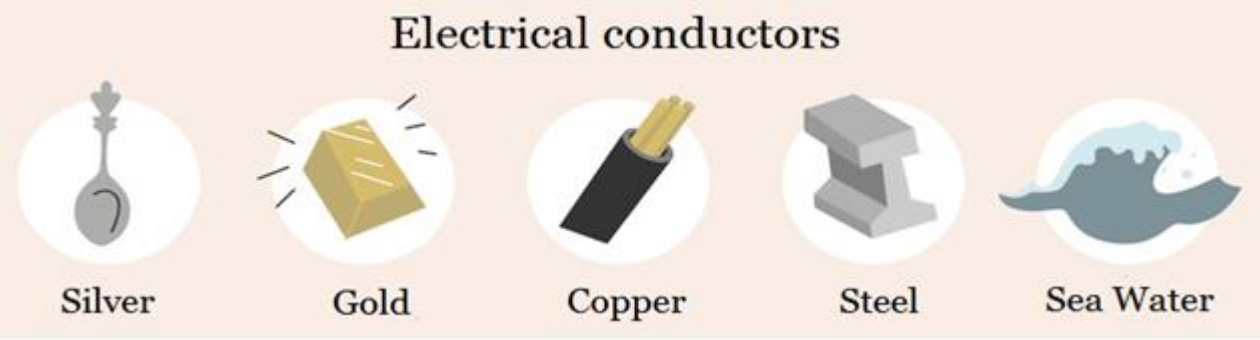
Electrical and Electronic Properties contd..>>

- Insulators>>

- Semiconductors>>



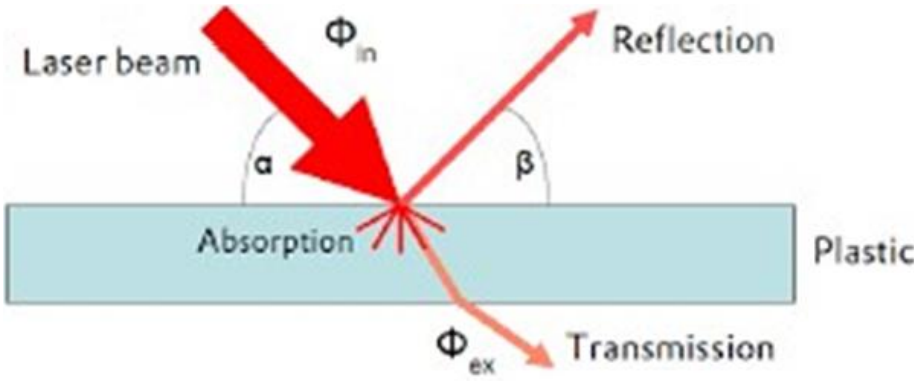
- Conductors>>



Engineering Materials>>

Optical Properties>>

- **Optical property** of a material is defined as its interaction with electro-magnetic radiation in the visible.
- **Materials are classified** on the basis of their interaction with visible light into three categories :
  - Transparent materials
  - Translucent materials
  - Opaque materials
- **Translucent materials:** These are the materials that are capable of transmitting light with relatively little absorption and reflection.
- **Translucent materials :** These are the materials those through which light is transmitted diffusely i.e. objects are not clearly distinguishable when viewed through.
- **Opaque materials:** These are the materials that are impervious to the transmission of visible light.
  - These materials absorb all the energy from the light photons.



Engineering Materials>>

Applications>>

Application of Engineering Materials

AGT
Academic Gain Tutorials

Ferrous Metals

> **Structural Purposes**
Building structures, Concrete reinforcement.

> **Automotive**
Chassis, engine parts, drive train and for body parts.

> **Marine**
Ship hulls, structures and engines.

> **Defense**
Tanks and weapons.

> **Consumer products**
Appliances, vehicles, toys, utensils and tools.

Non-Ferrous Metals

> **Architectural purpose**
Aluminum windows and doors.

> **Automotive**
Aluminum engine blocks, copper wiring and magnesium wheels.

> **Marine**
Brass and bronze fittings, bearings and propellers.

> **Defense**
Brass shell castings

> **Consumer products**
Electrical wiring, utensils, jewelry, electronics, etc.

Ceramic Materials

> **Automotive**
Valve components, backings in crankshaft housing etc.

> **Mechanical equipment**
High temperature and wear resistant cutting tools and pumps.

> **Electronics**
High power electronic capacitor insulation.

> **Medical**
Artificial bones and dental products.

> **Environment**
Water treatment, waste recycling, processing of raw materials

> **Aerospace**
Airframes, missile nose-cones, rocket nozzles

Composite Materials

> **Composite armors.**
Carbon fibre armors

> **Sports**
Sole of running shoe, shaft of arrow etc.

> **Aerospace**
In many sectors of aerospace industry.

> **Transportation.**

Polymers

Different polymers are used for different purposes:

> **ABS**
Refrigerator lining, garden equipment, toys, highway safety devices etc.

> **Acrylics**
Lenses, transparent aircraft enclosure, outdoor signs etc.

> **PTFE**
Anticorrosive seals, antiadhesive coatings, bearings, electronic parts etc.

> **Nylons**
Bearings, gears, cams

> **Polyethylene**
Flexible bottles, toys, battery parts, ice trays etc.

> **Epoxies**
Electrical moldings, adhesives, protective coatings etc.

Semiconductor Materials

A very wide range of applications of semiconductor materials are established nowadays.

Fundamentals of Mechanical Engineering

ENGINEERING MATERIALS

Assignment – Unit 1 - 04

<<for Practice>>

1) Explain with neat sketch ….
2) Brief about …..

Note:

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iii) Use red pen to write the questions and blue or black pen for answer
iv) Draw neat sketches using instruments (avoid free hand sketching)

Course Outcomes (COs):

Course Outcomes: After completing the course, the students will be able to:-	
CO 1	Understand the knowledge of various properties of Engineering materials and their Joining processes
CO 2	Elucidate the principles and operation of vision system in product inspection.
CO 3	Illustrate the Energy sources, mechanical drives and electrical drives in industrial applications
CO 4	Understand about Mechatronics, Automation and Robotics in Industrial Applications

References:

Reference Books	
1.	Elements of Mechanical Engineering, K. R. Gopalakrishna, Subhas Publications, 18th Edition. ISBN 5551234002884
2.	Material Science & Engineering- William D Callister, 2 / 10th Edition, ISBN 978-1-119-45520-2.
3.	Welding Technology (PB), Khanna O P, Dhanpat Rai publication, 4th Edition, ISBN 9383182555.
4.	Electric and Hybrid Vehicles, Design Fundamentals – Iqbal Husain, CRC Press, 2nd Edition, 2010. ISBN – 13-978-1439811757.
5.	Modern Electric, Hybrid Electric & Fuel Cell Vehicles, Fundamentals, Theory and Design - Mehrdad Ehsani, CRC Press, 1st Edition, 2005. ISBN – 13- 978-0849331541.
6.	Mechatronics – Electronic control systems in Mechanical and Electrical Engineering, William Bolton, Pearson, 6th Edition, ISBN: 978-1-292-07668-3, 2015.

Assessment and Evaluation Pattern:

CONTINUOUS INTERNAL EVALUATION		
ASSESSMENT AND EVALUATION PATTERN Theory & quizzes questions are to be framed using Bloom's Taxonomy Levels - Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating		
WEIGHTAGE	**CIE (50%)**	**SEE (50%)**
A. QUIZZES: Each quiz is evaluated for 10 marks		
Quiz-I for 10 Marks	**20**	*****
Quiz-I for 10 Marks		
B. TESTS: Each test will be conducted for 50 Marks adding upto 100 marks. Final test marks will be reduced to 40		
Test – I for 50 Marks	**40**	*****
Test – II for 50 Marks		
C. EXPERIENTIAL LEARNING: Fabrication of prototype of energy generator – 10 marks Fabrication of Mechatronics/Electrical/Mechanical drive prototype components– 20 marks Prototype models of Robot – 10 marks	**40**	*****
TOTAL MARKS FOR THE COURSE (A+B+C)	**100**	**100**

Practice to Prepare

All The Best