DESIGN THINKING AND INNOVATION

UNIT-I (Introduction to Design Thinking)

Introduction to elements and principles of Design, basics of design-dot, line, shape, form asfundamental design components. Principles of design. Introduction to design thinking, history of Design Thinking, New materials in Industry.

Design: plan of a system, its implementation, and utilization for attaining a goal (change undesired to desired)

Designing: How a design is developed (Both Goal and Plan)

Designs can be for: Technical systems, Educational systems, aesthetic systems (logo design, advertisements), legal systems, social, religious or cultural systems, theories, Models etc.

Design Vs Engineering Design

➢ Engineering is the practical endeavour in which the tools of mathematics and science are applied to develop cost effective solutions to the logical problems facing society.

➢ Engineers design many of the consumer products that needed in everyday life.

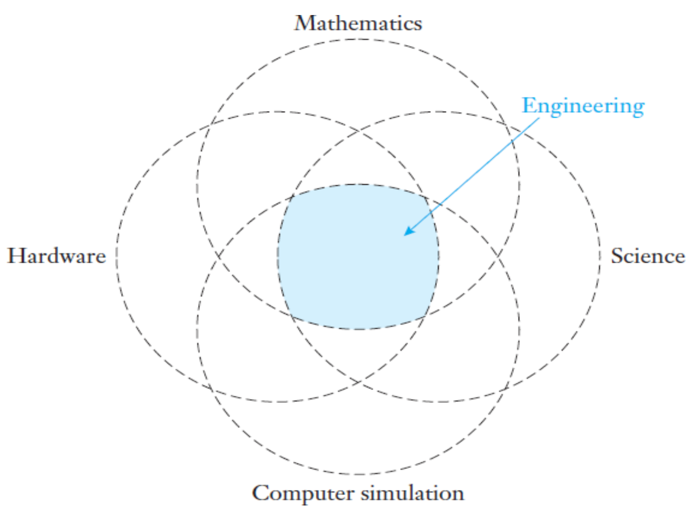
➢ Engineering is all about making useful things that work and impact lives

➢ The word “Engineering” derives from the Latin root in geniere, meaning to design or to devise, which also forms the basis of the word “ingenious’

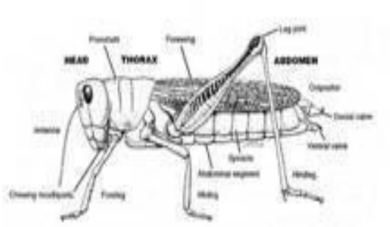
➢ Engineering is essentially a bridge between scientific discovery and product applications

➢ Engineers apply their knowledge of mathematics, science, and materials— as well as their skills in communications and business—to develop new and better technologies

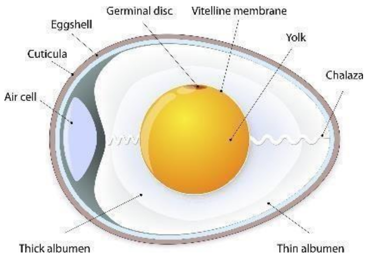
➢ Engineers combine their skills in mathematics, science, computers, and hardware



Designs inspired by nature:

Nature made	Man made
 Aves	 Flying suit
 Crane bird	 Crane
 Grasshopper	 Grasshopper structure

 Kangaroo pouch	 Baby pouch
 Snail	 Cd track

 **Spiral climber**	 **Stair case**
 **Egg**	 **Medicine capsules**
 **Human anatomy**	 **Pipes**

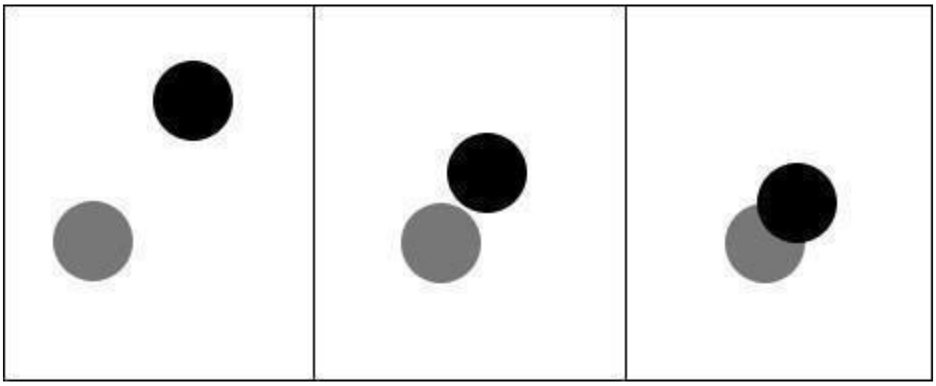
Elements of Design

Each element of design is a crucial part of a visual message, and the combination of these has an impact on how the design is perceived.

The following are the seven basic elements of design which are common throughout the field of designing

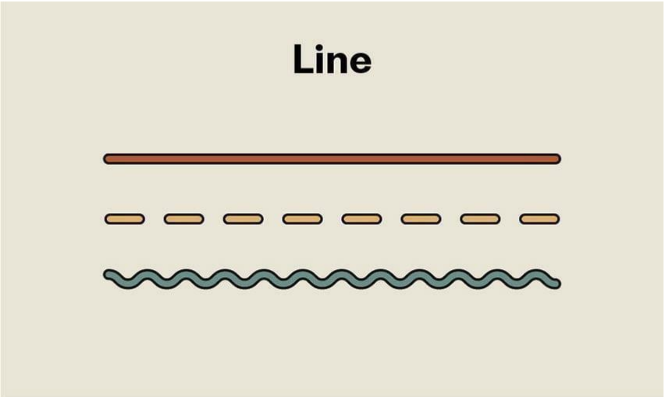
1. Point/Mark
2. Line
3. Shape
4. Forms
5. Space
6. Color
7. Texture

1. **Point/Mark**



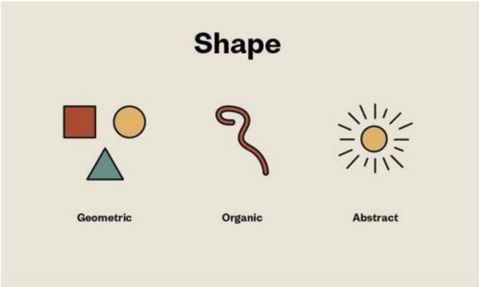
- A point or mark is the smallest and most basic element. It can vary in size, value, and regularity, and can be used alone as a unit in a group.
- Marks can be used to form a value or pattern (placed close together forms a darker value, further apart forms a lighter value), or to delineate space (larger means closer, etc)

2. **Line**



- A line is a form with width and length but no depth.
- Artist use lines to create edges, the outlines of objects. The direction of a line can convey mood.
- Lines are the most basic elements of design and can be used to define shapes, create patterns, and convey moment. They can be straight, curved, horizontal, vertical, diagonal, or even implied.

3. Shape



A shape in the elements of design is the result of enclosed lines to form a boundary. Shapes are two-dimensional and can be described as geometric, organic, and abstract.

- Geometric shapes have structure and are often mathematical and precise (squares, circles, triangles). Shapes can add emphasis to a layout.
- Organic shapes lack well-defined edges and often feel natural and smooth. Shapes add emphasis to a layout.
- Abstract shapes are a minimalist representation of reality. For instance, a stick figure of a person is an abstract shape. Logos are mostly represented by abstract figures to show the type of business.

4. Form (Positive Space)

- Forms describe volume and mass, or the 3D aspects of the objects that take up space
- Forms can and should be viewed from any angle.
- For example, when we hold a baseball or a small sculpture, we can be aware of their curves, angles, indentations, and edges i.e. their forms

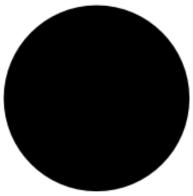
Form and shape are mutually dependent because changing one would affect the other. The spatial relationship between form and space can create attention and add 3D qualities to the design. Form and space will lend the design lots of visual activity that can help keep viewers engaged. To create a 3D effect in the design, we can add shadows, stack multiple elements, or play with color.

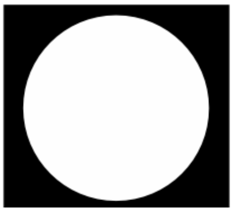
For example, the basic arch shape takes on form when depth is created with different shadows and highlight values in the below figure.

5. Space

- Space is the area used or unused in a composition; can contribute to balance within a composition
- Use of space can create dimension for the viewer; the area around, within, or between objects/subjects in an image creates perspective; positive and negative space.
- Positive space – the area the objects/subject takes up.
- Negative space – the area around, under, through and between.
- Foreground (closest), Middle ground, and Background (farthest).
- Can be open, crowded, near, far, etc.
- When used effectively, it can define importance and lead the eye.

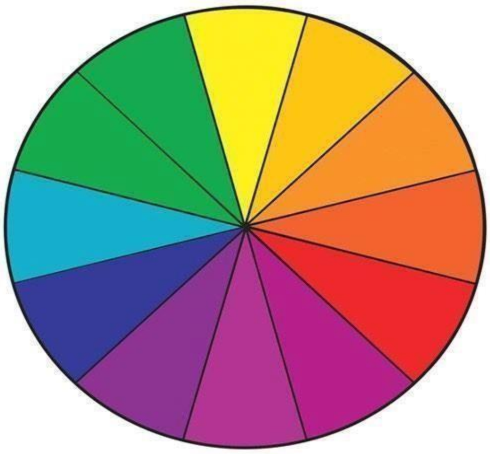
The following images are examples of positive and negative space respectively

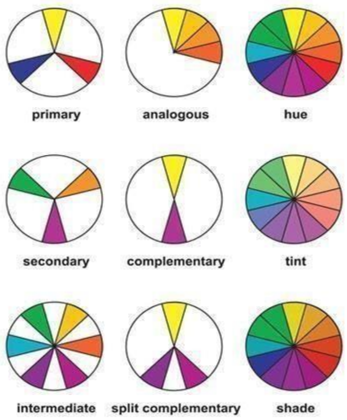




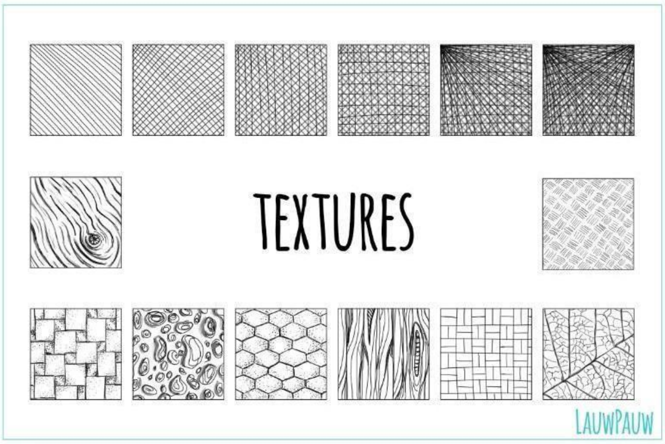
6. Color

- Color is a powerful element that can evoke emotions, create mood, and provide visual interest.
- Colors can be primary (red, blue, yellow), secondary (orange, green, purple) or tertiary (mixture of primary and secondary colors)
- Color has three properties hue(pure color with no black), tint(pure color mixed with white), shade(pure color mixed with black).





7. **Texture**
- Texture refers to the surface quality of an object, whether it is smooth, rough, bumpy, gooey, sharp, glassy etc.
- It adds depth and tactile qualities to visual design

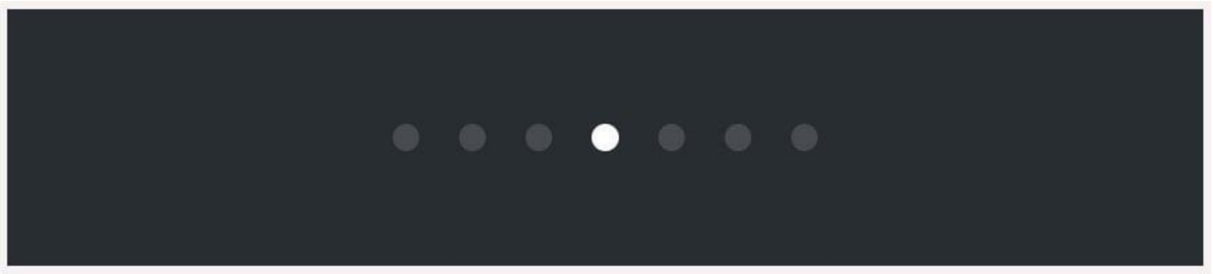


Principles of Design

The principles of design combine the elements to create a composition, they are the guidelines used to arrange the elements. Each principle is a concept used to organize or arrange the structural elements of a design and it applies to each element of a composition and the composition as a whole. The basic Design Principles are composed by:

Emphasis

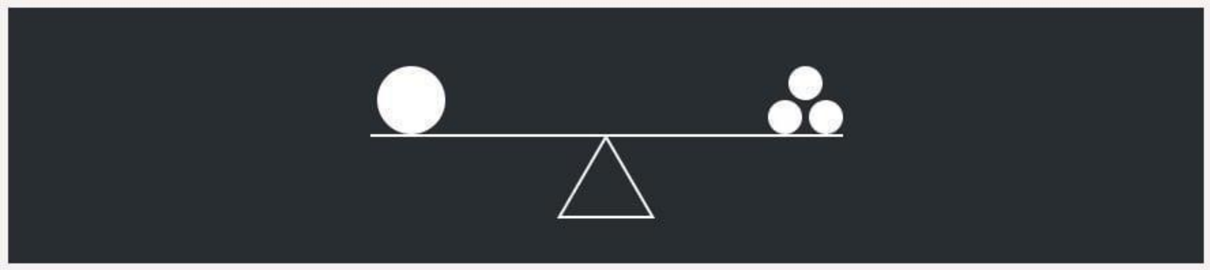
- It marks the location in a composition that most strongly draws the viewer attention, it is also referred to as the focal point.
- It is the most important area or object when compared to the other objects or areas in a composition.
- There are three stages of emphasis, related to the weight of a particular object within a composition: Dominant (the object with the most visual weight), Sub-dominant (the object or element of secondary emphasis) and Subordinate (the object with the least visual weight, which is usually the background).



Balance

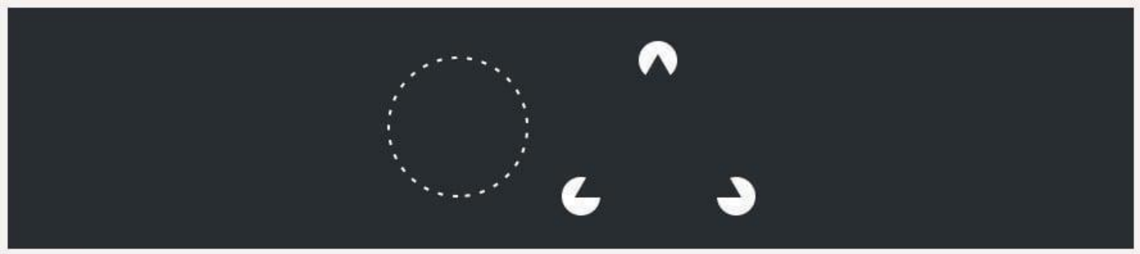
- Balance is the concept of visual equilibrium of similar, opposing, or contrasting elements that together create a unified whole.
- It refers to the appropriate arrangement of the objects in a design to create the impression of equality in weight or importance.

- It comes in 2 forms: Symmetrical (when the weight of a composition is evenly distributed around a central vertical or horizontal axis) and Asymmetrical (when the weight of a composition is not evenly distributed around a central axis).



Unity/Harmony

- Unity is used to describe the relationship between the individual elements and the whole of composition (which creates a sense of completeness, that all of the parts belong together) and it is a concept that comes from the Gestalt theory of visual perception and psychology.
- Three of the most well-known concepts of this theory are the
- Closure (is the idea that the brain tends to fill in missing information when it perceives an object is missing some of its pieces),
- Continuance (is the idea that once you begin looking in one direction, you will continue to do so until something more significant catches your attention) and
- Similarity, Proximity and Alignment (is the idea that elements of similar size, shape and color tend to be grouped together by the brain).



Contrast

- Contrast refers to the opposites and differences in the composition.
- We can achieve contrast by using different shapes, textures, colors and values in work.
- For example, something light against something dark, rough against smooth textures, etc.

Movement/Rhythm

- It is the visual flow through the composition, where (depending on the elements placement) the designer can direct the viewer´s eye over the surface of the design.
- The movement can be directed along edges, shapes, lines, color, etc and the purpose of movement is to create unity with eye travel.
- By arranging the composition elements in a certain way, a designer can control and force the movement of the viewer's eyes in and around the composition

Pattern/Repetition

- An object or symbol that repeats in the design is a pattern.
- It can be a pattern with a precise and regular repetition or an alternate pattern, which uses more than a single object or form of repetition. We can say that is simply keeping your design in a certain format.

Scale/Proportion

- Scale/Proportion is the comparative relationship in between two or more elements in a composition with respect to size, color, quantity, degree, etc, or between a whole object and one of its parts.
- The purpose of the proportion principle is to create a sense that has order between the elements used and to have a visual construction; and it can occur in two ways: Harmonious (when the elements are in proportion) or Unbalanced (when the disproportion is forced).
- It refers to the relative size and scale of the various elements in a design; the relationship between objects, or parts, of a whole
- For example, a person compared to large building, or different sized people in same photograph

Origin of Design Thinking:

Design to Design thinking

- Design or making, has been classically understood to be a process of turning ideas into things
- In this design process there is a vision or an idea, it can be figured out by some drawings work with fabrications of crafts and if everything worked out right then it be materialization.
- So, there is a direct correspondence between ideas, drawings, and finished products. This design process is called Direct Design
- Direct designs are criticized for not being responsive to real-world conditions.
- From an awareness of the power of engagement, a new and expanded form of design emerged called as Responsive design
- Responsive design came in many from environmental design to human-centered design
- In responsive design the most popular form is "Design thinking"

Definitions of Design Thinking

- Design thinking is a methodology that designers use to brainstorm and solve complex problems related to design and Design engineering.

Or

- Design thinking is a human-centered approach to innovation that draws from the designer's toolkit to integrate the needs of people, the possibilities of technology, and the requirements for business success— Tim Brown CEO of IDEO

Or

- There is no general agreement on precise definition of design thinking. There are variations across disciplinary cultures, and different meanings depending on its context

Or

- Design thinking is a human-centered innovation process that emphasizes observations, collaboration, fast learning, visualization, and rough prototyping. The objective is to solve not only the stated problems at hand but the real problems behind the obvious—Thomas Lockwood

About Design Thinking

Design thinking is a problem-solving approach that focuses on users and their emotional needs while experiencing products and services. It helps identify what adds value to various internal and external stakeholders in the organisational ecosystem.

Design thinking is a structured process to find solutions to complex human problems.

The uniqueness of the design thinking process is that it helps people to define and solve problems that are unstructured and have no historical references. It helps dissect problems that are complex and frame/reframe areas that require solutions.

There are several examples of where the application of Design thinking has been extraordinarily successful in design-led companies. Design has now evolved far beyond designing objects. Organisations now emphasise on learning how to think like designers and apply design principles at the workplace.

In several organisations globally (including the non-profit sector), Design thinking is at the core of strategy development and organisational change. It is being applied to pull in efficiency, make the optimum use of resources, and convert business models to more sustainable practices for the future.

Importance of Design Thinking

- **It provides human-centric techniques:** Human-centered design (HCD) is a methodology that places the user at the heart of the design process. It seeks to deeply understand users' needs, behaviors and experiences to create effective solutions catering to their unique challenges and desires.

- **Iterative Process**: The iterative process is the practice of building, refining, and improving a project, product, or initiative. Teams that use the iterative development process create, test, and revise until they're satisfied with the end result.

- **Redefines problems:** Design thinking is a non-linear, iterative process that teams use to understand users, challenge assumptions, redefine problems and create innovative solutions to prototype and test. It is most useful to tackle ill-defined or unknown problems and involves five phases: Empathize, Define, Ideate, Prototype and Test.

- **Promotes a solution-based approach:** Solution-based thinking promotes an iterative process where individuals or teams continuously refine and adjust their ideas until a practical solution is found. This approach is prevalent in design, innovation, and creative fields.

- **Develop empathy with the target user:** Design Thinking process involves developing a sense of empathy towards the people you are designing for, to gain insights into what they need, what they want, how they behave, feel, and think, and why they demonstrate such behaviors, feelings, and thoughts when interacting with products in a real-world.

- **Hands-on approach to prototyping and testing:** Prototyping is a form of validating and testing (and iterating and testing again) to gather constructive and timely feedback at an early stage in order to apply learnings back into product or service improvements. Refine—Refining involves narrowing your ideas down to one and making final refinements.

Objectives of design thinking:

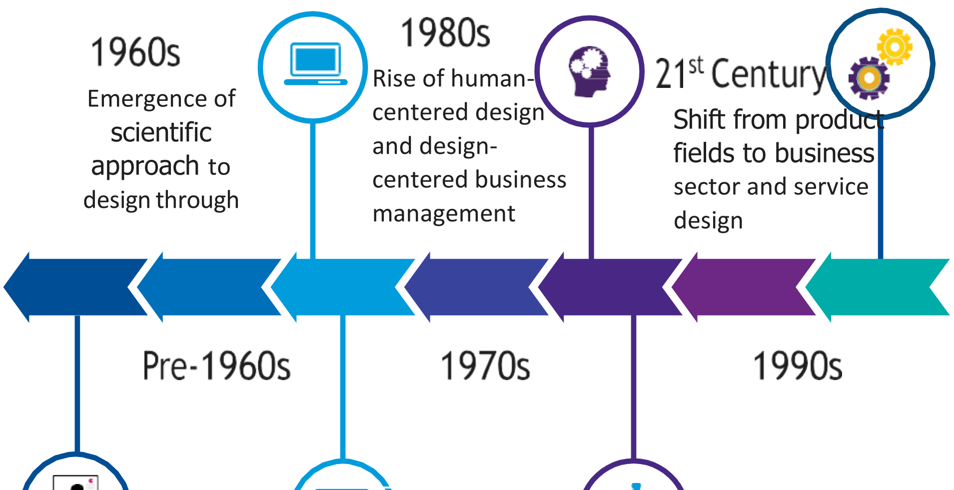
The objectives of the design need to match the performance objectives of the operation:

- **Quality -** products/services designed to specification and less wasted effort or need to recycle materials.
- **Speed -** shorter waiting times for customers, reduced need to maintain inventory levels.
- **Dependability -** deliver products/services on time, less need for disruption or rescheduling during the process.
- **Flexibility -** allows for a wide range of products/services. Enables fast but low cost change to timings, volumes and products/services.
- **Cost -** low processing costs, low resource costs and lower inventory costs.
- **Sustainability -** allows organizations to minimize energy usage (lower costs), reduce negative impact on local communities and reduced negative impact on environment.

Key characteristics and principles of Design Thinking:

- **Innovation:** Design Thinking encourages thinking outside the box and embracing new ideas and solutions.
- **User-Centric Approach:** Design Thinking focuses on understanding and meeting the needs of the users.
- **Problem Solving:** Design Thinking aims to identify and address problems creatively.
- **Collaboration and Multidisciplinary Teams:** Design Thinking involves teamwork and diverse expertise to generate innovative solutions.
- **Iterative and Agile Process:** Design Thinking is an iterative process where ideas are tested, refined, and improved upon.
- **Humanizing Technology:** Design Thinking seeks to create technology that is intuitive, accessible, and improves the human experience.
- **Enhancing User Experience:** Design Thinking focuses on creating products and services that provide a positive and seamless user experience.
- **Business Success:** Design Thinking can drive business success by creating innovative and user-centric solutions.
- **Adaptability and Future Readiness:** Design Thinking enables organizations to adapt to change and be prepared for the future.
- **Continuous Learning and Improvement:** Design Thinking values learning from failures, iterating, and continuously improving the design.

History or Evolution of Design Thinking:



Eminence of industrial design

Notable rejection of design method

Organizational learning and creating nimble

Design thinking has gone through a long journey of evolution.

In the pre 1960s era the foundation of the design thinking principles was laid, and was further reinforced during the Second World War era in the form of industrial design. With the progress in technology and invention of computer science, design moved to a more scientific approach, where design was pre-conceived using computers and then brought to production.

In the 1970s, design principles faced rejection as they could not keep pace with the fast evolving service economy.

During the 80s and 90s, there took place a resurgence – with design principles evolving and taking the shape of human-centred design. This resulted in the evolution of specialised design firms, providing design services.

The 21st century has seen the further evolution of Design thinking, as it is continues being applied to product development, service design, organisational strategy design, and so on. A design thinker should be good with working in teams, empathetic towards humansand humanity, and willing to try and ready to fail to design in the 21st century. The designer's mindset is highly insight-oriented. The designer is typically an out-of-the-box thinker, a problem solver, and always maintains the consumer's requirement at the crux of all creation/ideation.

New Materials in Industry

The new material developments allow designers to explore from a human-centric design approach. The innovation in materials acts as a driving force for designers to think, re-think, and innovate.

Here are some ways new materials can impact design thinking:

1. **Sustainability:** New materials can offer eco-friendlier alternatives, reducing waste and environmental impact.

2. **Functionality:** Advanced materials can provide improved performance, durability, and functionality in products.

3. **Aesthetics:** New materials can enable innovative textures, colors, and visual effects, expanding design possibilities.

4. **Manufacturing:** Emerging materials can simplify production processes, reduce costs, and enable new manufacturing techniques.

Some examples of new materials in industry include:

1. **Graphene (Nano Material)**

Graphene is a material that is extracted from graphite and is made up of pure carbon, one of the most important elements in nature and which we find in daily objects like the lead of a pencil.Graphene stands out for being tough, flexible, light, and with a high resistance. It's calculated that this material is 200 times more resistant than steel and five times lighter than aluminum.

With these properties, graphene has applications in the energy, construction, health, and electronics sectors. For instance, magnetic graphene could transform this electronics industry by making devices more comfortable and accessible for everyone.

Among the diverse properties of graphene, the ones that stand out most are its high thermal and electrical conductivity, elasticity, toughness, lightness, and resistance. These characteristics could be of great use for innovation in different sectors and represent a real revolution. Let’s see some examples:

Characteristics and properties of grapheme:

1. **High conductivity:**

Through the use of graphene, the useful life of batteries could be increased by 10, as well as charging in less time, which translates into an autonomy improvement. It's only a matter of time before graphene replaces a large part of the lithium batteries currently in use.

2. **Lightness:**

Graphene is also suitable for manufacturing batteries for drones, as these would be lighter and tougher. Let’s remember that these pieces that accumulate energy are some of the heaviest in technology and reducing their weight could be a great innovation.

3. **Transparency and flexibility:**

Graphene is a transparent material and absorbs very little light (only 2%). It is flexibility, flexible screens could be manufactured for all types of devices.

4. **High resistance:**

As well as being an excellent electric conductor, graphene is a very resistant material, so big advances in the lighting sector are expected. For example, graphene light bulbs could increase the useful life of each globe and consume less energy than the LED lights.

<u>Uses and applications of graphene:</u>

1. **Graphene in the energy sector:**

	The use of graphene in the manufacturing of rechargeable batteries could be a great leap towards energy efficiency. This material would prevent devices overheating, so they would be tougher and lighter. Applied to different materials in our homes, it could contribute to a better thermal regulation of the home and a saving in the air conditioning of spaces. For example, using paint with graphene.

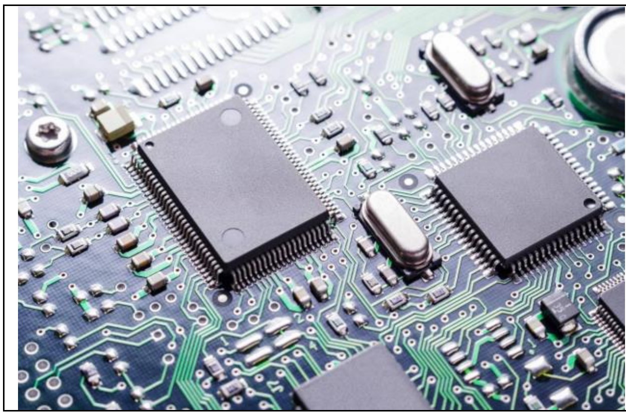
2. **Graphene in construction:**

	The use of graphene applied to construction promises to improve the insulation of buildings. And not just that, but they could be more resistant to corrosion, dampness, and fire, and therefore tougher and more sustainable. Construction materials would be perfected and eco-friendly components would be used, such as "green concrete," an eco-efficient material that is more sustainable and resistant than the current one.

3. **Graphene in Health:**

	The applications of graphene in the health and medicine sectors are also fascinating. The properties of graphene, stronger, more flexible, and lighter hearing aids could be developed. We could even be speaking about making bones and muscles that would be introduced through surgical operations. Still in the research phase, it's believed that graphene oxide could be a good ally in the diagnosis of diseases and their subsequent treatment. This is an element that's obtained when graphene is oxidized, converting it into a material with extraordinary mechanical properties.

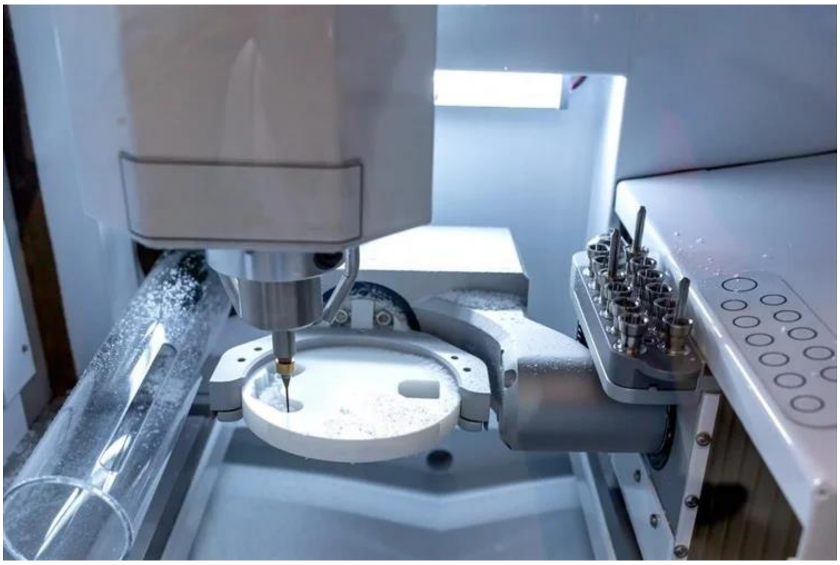
4. **Graphene in electronics:**

	With the application of this material, smaller, lighter, tougher, and more efficient devices could be manufactured, impossible to obtain with the components that are used today. Furthermore, graphene applied to electronic circuits would make devices ‘immune’ to dampness, one of the main causes of deterioration. In addition, it has excellent thermal and electrical conductivity, which is 1,000 times better than that of copper.

2. Advanced ceramics

Ceramics have evolved significantly from their traditional use in pottery to become essential materials in various industries. Advanced ceramics, with their unique properties, are now integral to electronics, aerospace, energy generation, and other industrial sectors.

When machinery is equipped with ceramic components, it resists heat and wear and offers scratch-resistant screen properties. Advanced Ceramics is on its way to becoming a popular choice as sustainability becomes mainstream across processes. Advanced ceramics are a key enabling technology for many applications in the aerospace, defence, power generation, and industrial processing industries that have a significant national impact with economic and environmental contributions.



These advanced ceramics are classified into oxides, non-oxides, and composites. Oxides form the largest group, comprising ceramics based on metal oxides like alumina (Al2O3), zirconia (ZrO2), and titania (TiO2), known for their exceptional high-temperature stability, chemical resistance, and wear resistance.

In contrast, non-oxide ceramics like silicon carbide (SiC), boron nitride (BN), and silicon nitride (Si3N4) do not contain oxygen but offer superior mechanical properties like high strength and hardness, making them ideal for wear applications and high-temperature environments.

Advanced ceramics have distinct properties that set them apart from traditional ceramics and metals. They have high abrasion resistance and significantly outperform metals in wear resistance, making them ideal for applications like grinding media and cutting tools.

3. Mycelium

Mushrooms are already known for their leather-like property that is revolutionizing the vegan leather industry. However, innovators and scientists have dug deeper under the mushroom plants to find the material Mycelium. It is considered often as the body of the mushroom and it's at times a hundred times larger than the oyster or button-shaped tiny mushroom that grows from the ground up.

Mycelium-based composites (MBCs) have attracted growing attention due to their role in the development of eco-design methods.

Mycelium-based composites are used in construction, packaging, and in the production of various types of products.

Mycelium eliminates or minimizes the need for additional bonding materials. When two mycelium bricks are placed together, they rapidly intermingle and form a natural bonding connection, simplifying the construction process.

Mycelium can be used to manufacture a variety of durable, biodegradable materials, such as the following:

Leather:

Mycelium leather can be tanned and dyed to mimic the look, feel, and texture of leather and other synthetic fabrics. Adidas is currently at the forefront of this revolution, having recently released its first Mylo leather shoe—the Stan Smith Mylo.

Packaging:

Mycelium foam makes a great alternative to conventional polystyrene or polyurethane packaging foam. It's lightweight, breathable, flame-resistant, and inexpensive. IKEA is one of the retailers leveraging this environmentally-friendly packaging solution.

Building materials:

Mycelium can replace conventional building materials with lightweight, inexpensive, and durable alternatives like building blocks, styrofoam, wall tiles, and particle boards. These mycelium-based materials are biodegradable, strong, fire-resistant, and provide excellent insulation.

Using mycelium as an alternative material is great for the environment in the following ways:

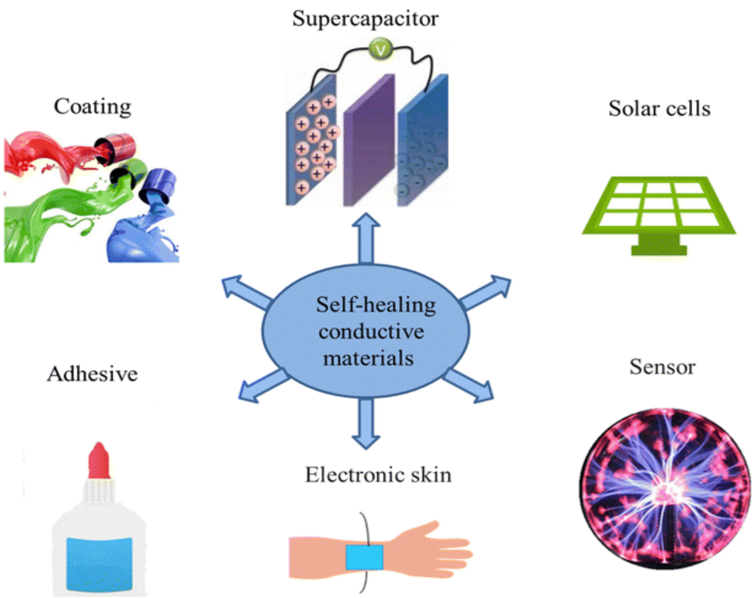
- It consumes less energy.
- It produces fewer emissions.
- It does not require the many chemicals used in producing plastic-based materials.
- It is easy, quick, and sustainable to produce.

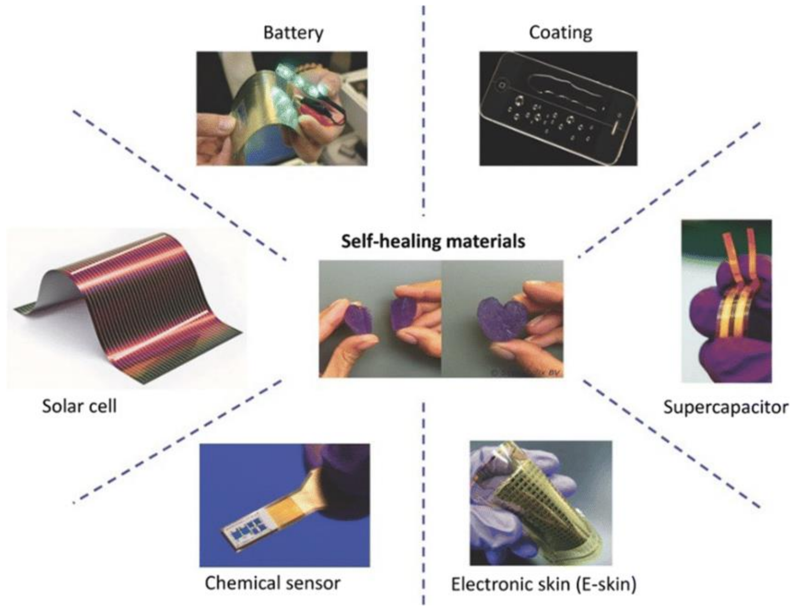
4. Self-healing materials

This self-healing material means one that can 'mend' itself over some time. A material with property to reverse any damage caused to them. These materials are often mixed with other specific elements like fibers or capsules into a say, concrete mix that contains repairing solutions. Self-healing materials are also part of paints and coating which allow scratches on automobiles to disappear when exposed to UV light or natural light.

Empowering materials with self-healing capabilities is an attractive approach for sustainable development. This strategy involves using different methods to automatically heal micro cracks and damages that occur during the service life of materials or structures.

Additionally, some self-healing materials undergo reversible chemical reactions that allow them to repair themselves when damaged. A variety of classes of materials, including metals, glass, rubber, silicon, cotton, leather, ceramics, concrete, and polymers, are a few examples of tested self-healing components.



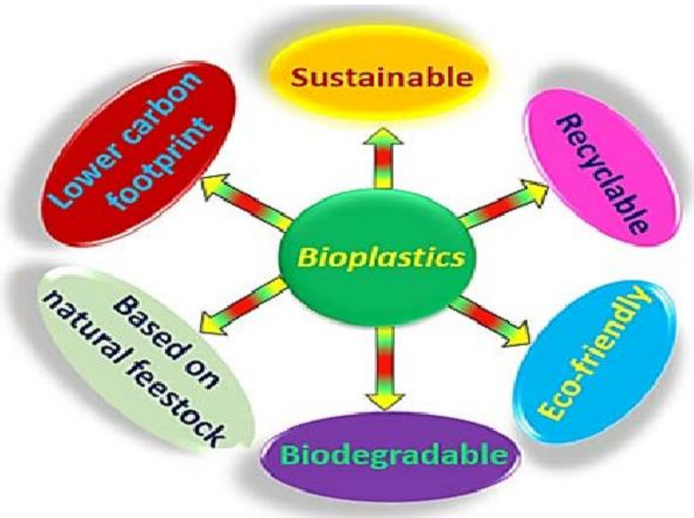


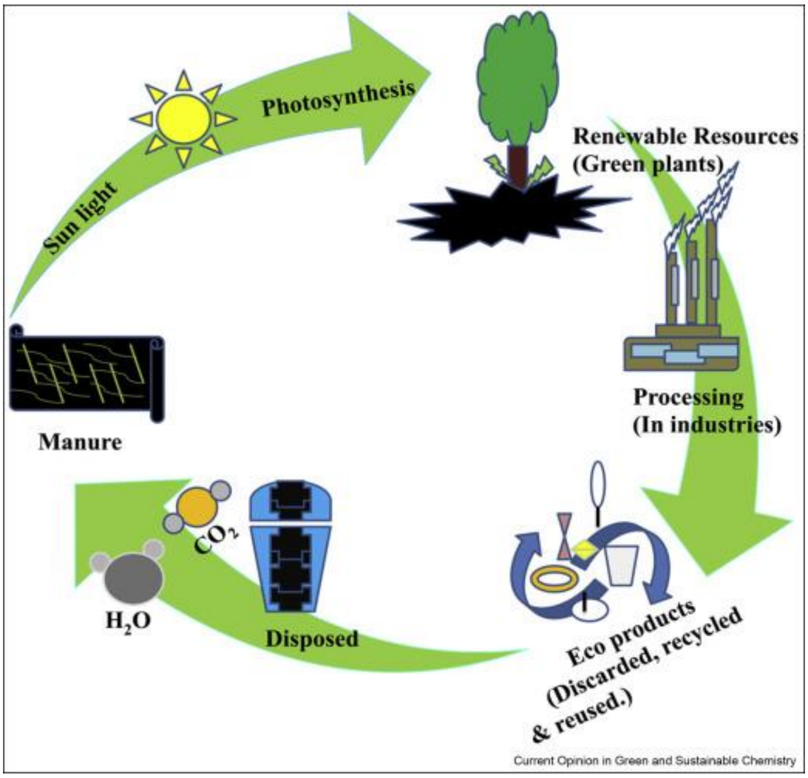
5. Bioplastics and Bio composites

Bioplastics and Bio composites have the advantage of being biocompatible and degradable. They are the main ingredient in making nature-friendly materials while reducing waste. Helping designers to work with a material that aids in solving the waste management issue of modern history. They are easy to make and access, making them a popular choice for product designers to do their R&D. Renewable, biodegradable plastics made from biomass sources likecorn starch or sugarcane

Bio-composites are the blend of regular strands, for example, wood filaments (hard wood and soft wood) or non-wood strands (hemp, sugarcane, rice straw, jute, banana, pine apple, oil palm, sisal, and flax) with polymer matrices from both of the sustainable and non-inexhaustible assets.

Bio based plastics also have the unique potential to reduce GHG emissions or even be carbon neutral. Plants absorb atmospheric carbon dioxide as they grow. Using plants (i.e. biomass) to produce bio based plastics constitutes a temporary removal of greenhouse gases (CO2) from the atmosphere.




Photosynthesis
Sun light
Renewable Resources
(Green plants)
Processing
(In industries)
Manure
CO_2
H_2O
Disposed
Eco products
(Discarded, recycled
& reused.)
Current Opinion in Green and Sustainable Chemistry