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Internal Assessment Test 3 – August 2024									
Sub:	**Biology for Engineers**				Sub Code:	**BBOK407**	Branch:	**ECE**	
Date:	**02/08/2024**	Duration:	90 Minutes	Max Marks: 50	Sem/Sec:	**4/A, B, C, D**		**OBE**	

	Answer Any 5 Questions	MARKS	CO	RBT
1	Explain in about Super hydrophobic and self-cleaning surfaces	[10]	CO4	L2
2	What is Shark skin effect and explain in detail	[10]	CO4	L2
3	What is the concept behind the Kingfisher beak	[10]	CO4	L2
4	Explain the following i) sonars ii) photovoltaic.	[10]	CO4	L2
5	Describe the materials used and engineering applications of Velcro technology.	[10]	CO4	L2
6	Illustrate the HBOCs & PFCs as human blood substituents.	[10]	CO4	L2
7	Compare and contrast biological echolocation and technological echolocation, highlighting their applications and significance in navigation and detection.	[10]	CO4	L2

CI CCI
HOD

1. Explain in about Super hydrophobic and self-cleaning surfaces

Superhydrophobic Surfaces: Superhydrophobic surfaces are characterized by their ability to repel water, resulting in very high-water contact angles, typically above 150°. This property is inspired by natural phenomena such as the lotus leaf, which exhibits extreme water repellency due to its micro- and nanoscale surface structures. The concept relies on minimizing the surface energy so that water droplets roll off easily, carrying away dirt particles. The creation of superhydrophobic surfaces typically involves the combination of low surface energy materials (like fluoropolymers) and surface roughness at the microscopic or nanoscopic scale.
Self-Cleaning Surfaces: Self-cleaning surfaces are surfaces that can clean themselves, primarily by repelling water and dirt. These surfaces utilize the superhydrophobic property to allow water droplets to pick up and carry away contaminants as they roll off. The most famous example is the lotus leaf, leading to the term "lotus effect." In engineering, self-cleaning surfaces are developed for applications in various fields such as textiles, glass coatings, solar panels, and medical devices, where maintenance and cleanliness are crucial.

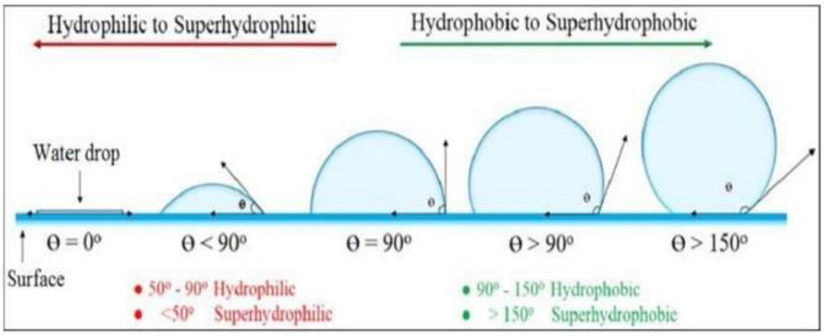
Applications:

- **Textiles**: Clothes that resist staining and dirt.
- **Solar Panels**: Maintaining efficiency by preventing dust accumulation.
- **Medical Devices**: Ensuring hygiene and reducing infection risks.

Mechanism:
The mechanism behind these surfaces involves creating a rough texture combined with a material that has low surface energy. When water encounters such a surface, the contact angle is so high that it forms droplets that easily roll off, rather than spreading out. These droplets pick up dirt as they move, cleaning the surface in the process. Superhydrophobic and self-cleaning surfaces are revolutionary in various engineering fields, offering low-maintenance solutions that mimic natural processes. Continued research in this area is likely to lead to more advanced materials with even greater efficiency and broader applications.

Applications:

1. Super Hydrophobic Effect & Self-cleaning surfaces



Materials Used
- Fluoropolymers
- Metal Complex
- Carbon-based materials
- Silica Nanoparticles
- Hybrid Nanocomposites

Techniques
- CVD / PVD
- Sol-Gel
- Electrochemical
- Plasma
- Spray Pyrolysis, Laser Ablation
- Photolithography

2. Bionic Leaf:
A bionic leaf is a system that uses artificial photosynthesis to convert sunlight into usable forms of energy, such as hydrogen or other biofuels.
The bionic leaf is designed to mimic the process of photosynthesis in plants, where light energy is used to split water molecules into hydrogen and oxygen, and the hydrogen can then be used as a source of energy.
First Step: Sunlight is captured and directed to the bionic leaf.

The bionic leaf contains a catalyst (typically a special type of bacteria or an artificial catalyst) and a water-splitting enzyme.

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Sunlight energy is used to split water molecules (H_2O) into hydrogen ions (H^+) and oxygen (O_2) through a process called photolysis.

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The hydrogen ions (H^+) generated from water splitting combine with electrons from an external source (e.g., a wire) to form hydrogen gas (H_2).

↓

The oxygen gas (O_2) produced during water splitting is released into the atmosphere.

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The generated hydrogen gas (H_2) can be collected and stored for later use as a clean and renewable energy source.

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The bionic leaf also absorbs carbon dioxide (CO_2) from the air or a supplied source.

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The absorbed carbon dioxide (CO_2) is converted into carbon-based compounds, such as formic acid or methane, through a reduction reaction.

↓

The carbon-based compounds can be used as a fuel or converted into other useful chemicals.

Last Step: The bionic leaf operates in a closed-loop system, where the produced oxygen (O2) during water splitting is reused by the catalyst in subsequent cycles.

2. What is Shark skin effect and explain in detail

The "Shark Skin Effect" refers to a phenomenon observed in fluid dynamics, particularly in relation to the surface texture of shark skin. Sharks have a unique skin structure composed of tiny, tooth-like scales called dermal denticles. These denticles reduce drag and turbulence in water, allowing sharks to swim efficiently and quickly.

Detailed Explanation:
Structure of Shark Skin:
Dermal Denticles: Shark skin is covered with dermal denticles, which are small, rigid, and V-shaped scales. Unlike typical fish scales, these denticles are more akin to tiny teeth. They have grooves running along their length, which are oriented parallel to the direction of water flow.
Function: The grooves and overall rough texture of the dermal denticles minimize the friction between the water and the shark's body. This reduction in friction decreases drag and turbulence, enabling the shark to swim more efficiently.

Mechanism of Drag Reduction:
Laminar Flow: The grooves on the denticles help maintain a laminar flow of water over the shark’s body. Laminar flow is characterized by smooth, parallel layers of water moving over a surface, which reduces drag.
Turbulence Management: By controlling the boundary layer (the thin layer of fluid close to the skin), the denticles reduce the size and impact of vortices or eddies that form in the turbulent flow. This leads to less energy being lost to drag, which is crucial for fast swimming.

Applications of the Shark Skin Effect:
Engineering and Design: The shark skin effect has inspired various technological applications, particularly in the fields of marine engineering and aviation. For example, shark skin-inspired coatings are applied to the hulls of ships and submarines to reduce drag and increase fuel efficiency. Similarly, this effect is explored in aircraft design to improve aerodynamics.

Textiles and Sportswear: Some competitive swimwear, like those used in the Olympics, mimics the texture of shark skin to reduce drag and improve swimmers' speed.

Medical Field: The antimicrobial properties of shark skin have also inspired medical applications, such as creating surfaces that prevent bacterial growth in hospitals and other environments.

Significance:

The shark skin effect represents a brilliant example of biomimicry, where natural biological designs inspire human-made technologies. By studying and replicating the unique properties of shark skin, engineers and scientists can develop more efficient and environmentally friendly solutions in various industries. The shark skin effect is a remarkable natural adaptation that has significant implications for technology and engineering. By reducing drag and turbulence, sharks are able to swim with incredible efficiency. This principle, when applied to human technology, holds the potential for enhancing the performance and sustainability of various systems, from vehicles to medical devices.

3. What is the concept behind the Kingfisher beak

Kingfisher Beak and Bullet Train – Aerodynamic Design & Pressure Wave Reduction

The kingfisher beak is an excellent example of nature's design for efficient diving and fishing.
Its unique shape and structure enable the kingfisher to minimize the impact of water resistance and achieve a successful dive.

The Physics Behind the Kingfisher Beak Streamlining:

- ❖ The beak of a kingfisher is long, slender, and sharply pointed, which helps reduce drag or air resistance as the bird dives into the water.
- ❖ The streamlined shape allows the kingfisher to cut through the air and minimize the energy required for the dive.

Surface Tension
Minimizing Disturbances

Materials Used

The materials used to create friction-reducing swimsuits inspired by shark skin include:

Polyurethane: A type of polymer that is commonly used in the production of swim suits, as it is durable and can be molded into a variety of shapes.

Lycra/Spandex: Lycra and spandex are made from the same synthetic fibre, which is technically called Elastane.

Elastane fibers are typically composed of a polymer called polyurethane which is then blended with other fibers like nylon, polyester, or cotton) that is known for its stretch and flexibility.

High-tech fabrics: A range of high-tech fabrics have been developed specifically for use in swimsuits. These fabrics are designed to be lightweight, water-repellent, and hydrodynamic, and often incorporate materials such as silicone or Teflon to reduce drag.

4. Explain the following i) sonars ii) photovoltaic.

Sonars

Sonar, which stands for Sound Navigation and Ranging, is a technology that uses soundwaves to detect and locate underwater objects

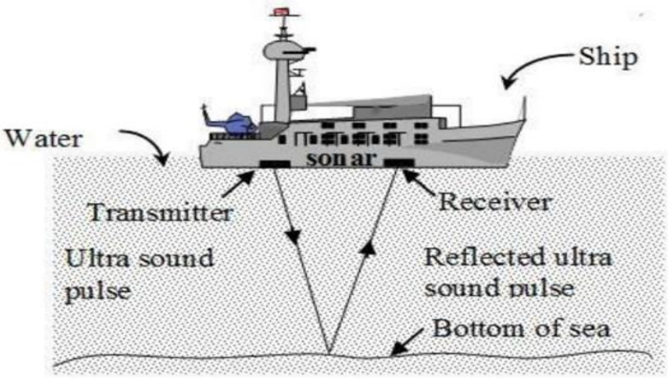
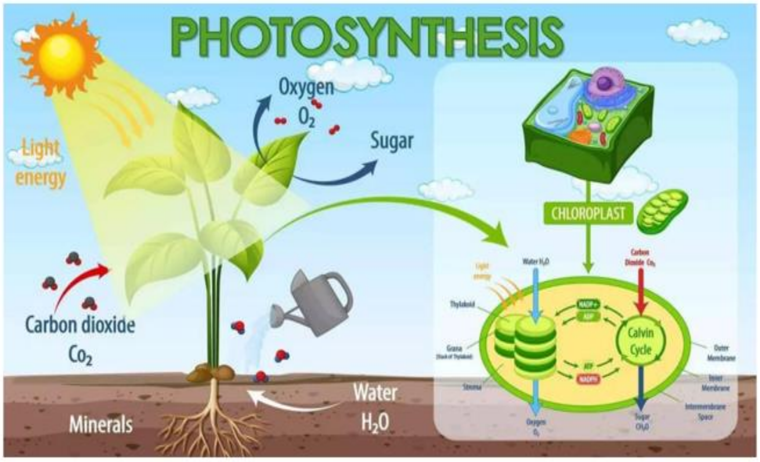


Figure: Representing working principle of sonar

Photosynthesis

Photosynthesis is the process by which plants, algae, and some bacteria convert light energy from the sun into chemical energy stored in organic molecules. This process is critical for life on Earth, as it provides the primary source of energy for all living organisms.

- ❖ The process of photosynthesis in plants and some animals differs in terms of the type of organisms involved and the specific details of the process.
- ❖ However, the basic principle of converting light energy into usable forms of energy is the same in both.



In plants, photosynthesis takes place in the chloroplasts of the cells located in the leaves.

- ❖ The process starts with the absorption of light energy by pigments such as chlorophyll, which then excites electrons.
- ❖ These excited electrons are used to power the transfer of carbon dioxide into organic molecules, such as sugars and starches, through a series of chemical reactions.
- ❖ The end product of photosynthesis in plants is stored chemical energy in the form of organic compounds.

In some animals, such as algae, photosynthesis also takes place in chloroplasts.

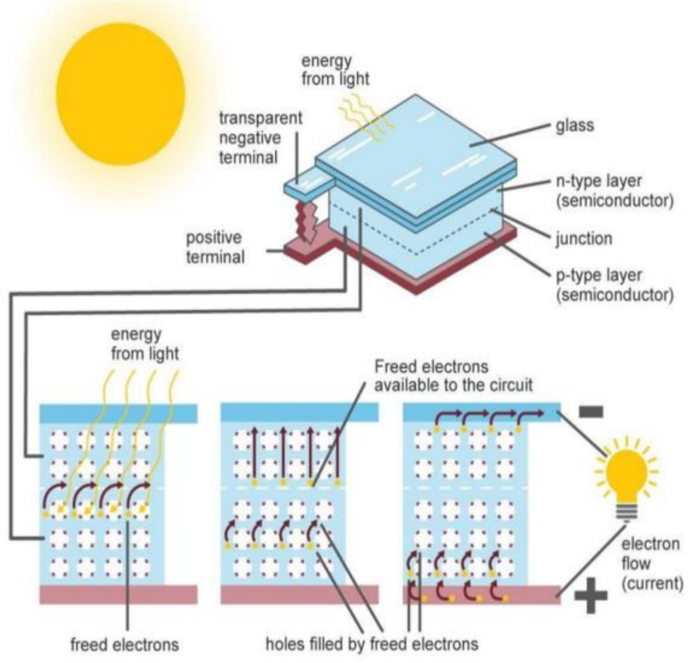
- ❖ The process is essentially the same as in plants, with the absorption of light energy and the conversion of carbon dioxide into organic molecules.
- ❖ In contrast, some animals, such as jellyfish, have a symbiotic relationship with photosynthetic organisms, such as algae. In this relationship, the animal provides a safe and stable environment for the photosynthetic organism, while the photosynthetic organism provides energy in the form of organic compounds produced through photosynthesis.

❑ ***Light-dependent reactions and light-independent reactions (also known as the Calvin cycle) are two interconnected processes that occur in the chloroplasts of plants and algae during photosynthesis.***

Photovoltaic Cells

Some new technologies in photovoltaic cells

- ❖ Perovskite solar cells
- ❖ Thin Films
- ❖ Concentrator
- ❖ Multi-junction



5. Describe the materials used and engineering applications of Velcro technology

Materials Used in Velcro Technology

1. Nylon

Nylon is the most common material used in Velcro technology, particularly for the hook side. It is chosen for its strength, flexibility, and resistance to wear and tear. Nylon can be molded into tiny hooks that catch the loops on the other side of the fastener.

2. Polyester

Polyester is often used for the loop side of Velcro fasteners. This material is durable, soft, and resistant to environmental factors like moisture and UV light, which makes it ideal for outdoor and heavy-duty applications.

3. Polypropylene

Polypropylene is sometimes used in Velcro for its chemical resistance and lightweight properties. It is especially useful in applications requiring a more rigid and durable fastening system.

4. Elastic Materials

In some Velcro products, elastic materials are incorporated to provide flexibility and stretch. These are often used in applications where the fastener needs to conform to different shapes or where a snug fit is necessary.

5. Adhesive Backing

For self-adhesive Velcro products, a layer of strong adhesive is applied to the back of the hooks or loops, allowing the fastener to be attached to surfaces without sewing. This adhesive is typically made of pressure-sensitive materials that bond to a variety of substrates, including fabric, plastic, and metal.

Engineering Applications of Velcro Technology

1. Aerospace

Velcro is extensively used in aerospace engineering, particularly in spacecraft, where it helps secure tools, equipment, and even food trays in zero-gravity environments. It is also used in space suits and other gear where reliable fastening is crucial.

2. Medical Devices

In the medical field, Velcro is used in braces, splints, and other orthopedic devices where adjustable fastening is required. It provides a secure but easily adjustable fit, making it ideal for applications that require frequent adjustments.

3. Automotive Industry

Velcro is used in the automotive industry to secure carpets, upholstery, and interior panels. It is also used in the assembly of removable panels and other components that need to be easily accessible for maintenance or replacement.

4. Apparel and Footwear

Velcro is widely used in clothing, shoes, and accessories. It is particularly popular in children's shoes and apparel, where ease of use is important. Velcro is also used in sportswear and outdoor gear, where quick and secure fastening is needed.

5. Military and Tactical Gear

The military uses Velcro in uniforms, tactical gear, and equipment attachment systems. It allows for the easy attachment and removal of pouches, patches, and other gear components, making it a versatile fastening solution in the field.

6. Industrial Applications

In industrial settings, Velcro is used to secure cables, organize tools, and fasten components in machinery. Its durability and ease of use make it a practical solution in environments where traditional fasteners may not be suitable.

6. Illustrate the HBOCs & PFCs as human blood substituents.

Human Blood Substitutes

Introduction Human blood substitutes are synthetic products that are designed to act as a replacement for blood in the human body.

Basic Requirement for Human Blood Substitutes

- **Effective Oxygen Transport**
- **Safety and Compatibility**
- **Storage and Transport**
- **Cost-Effectiveness and Scalability**

Types of HBS

There are two types of human blood substitutes - hemoglobin-based oxygen carriers (HBOCs) and perfluorocarbons (PFCs).

HBOCs are based on the haemoglobin molecule, which is the **protein in red blood cells that carries oxygen to the body's tissues.**

Hemoglobin is extracted from human or animal blood and then modified to create a stable, synthetic version. When introduced into the body, HBOCs can help to increase the **amount of oxygen available to the tissues**, which can be important in situations where the body is unable to produce or transport enough red blood cells.

PFCs are synthetic molecules that are similar in structure to the haemoglobin molecule. However, unlike HBOCs, they do not require modification from natural sources. PFCs are able to dissolve oxygen and transport it throughout the body, similar to the way that red blood cells work.

7. Compare and contrast biological echolocation and technological echolocation, highlighting their applications and significance in navigation and detection.

1. Biological Echolocation

Definition and Mechanism
Biological echolocation is a natural navigation and detection system used by various animals, including bats, dolphins, and certain species of birds. These animals emit sound waves (often ultrasonic) that travel through the environment. When these sound waves hit an object, they bounce back as echoes, which the animal's highly specialized auditory system interprets to determine the object's size, shape, distance, and even texture.

Applications
1. Navigation: Bats use echolocation to navigate through dark environments, such as caves, where vision is limited.
2. Hunting: Dolphins and some bats use echolocation to locate prey, even in murky waters or pitch-dark conditions.
3. Communication: Certain animals use echolocation clicks to communicate with others in their species, transmitting information about their environment.

Significance
Biological echolocation is crucial for survival, especially in environments where other senses (such as sight) are less effective. It allows animals to navigate complex environments, find food, and avoid predators.

2. Technological Echolocation

Definition and Mechanism
Technological echolocation, often referred to as sonar (Sound Navigation and Ranging), is a man-made system that uses sound waves to detect objects and navigate underwater or in the air. Like biological echolocation, sonar systems emit sound pulses that reflect off objects and return as echoes. These echoes are analyzed to determine the location, distance, and characteristics of the objects.

Applications
1. Marine Navigation: Sonar is widely used in submarines and ships to navigate underwater, avoid obstacles, and detect other vessels.
2. Medical Imaging: Ultrasound, a form of sonar, is used in medical diagnostics to create images of internal body structures, such as monitoring fetal development during pregnancy.
3. Environmental Monitoring: Sonar systems are used to map the seafloor, monitor fish populations, and study underwater ecosystems.
4. Military Use: Sonar is crucial in military applications for detecting enemy submarines, mines, and other threats underwater.

Significance
Technological echolocation has revolutionized fields such as marine navigation, medical imaging, and environmental science. It enables precise detection and navigation in environments where other technologies, like radar or visual systems, are ineffective.

Comparison and Contrast

Similarities:
Both biological and technological echolocation operate on the same basic principle—emitting sound waves and analyzing the returning echoes to gather information about the environment. Both systems are used for navigation, detection, and communication in environments where other senses or technologies are limited. Both rely heavily on the speed of sound and the properties of sound waves to interpret their surroundings.

Differences:

Biological echolocation evolved naturally over millions of years, while technological echolocation was developed by humans, inspired by the natural system. Biological echolocation is typically used in air or water by living organisms, whereas technological echolocation is often used underwater in the form of sonar, although ultrasound is used in air and body tissues for medical imaging. Biological echolocation involves highly specialized organs and brain regions, while technological echolocation uses electronic devices and computers for sound emission, reception, and data analysis.

Applications: While biological echolocation is used for survival by animals, technological echolocation has a broader range of applications, including military, medical, industrial, and environmental uses. Both biological and technological echolocation are critical for their respective domains. Biological echolocation showcases the remarkable adaptations of certain species, while technological echolocation has enabled significant advancements in various human activities. The study of biological echolocation has also inspired and informed the development of sonar and other technological echolocation systems.

Application 1:

Ultrasonography

- Ultrasonography is a medical imaging technique that uses high-frequency sound waves to produce images of the internal organs and tissues of the body. It is also known as ultrasound imaging or sonography.
- The ultrasound machine emits high-frequency sound waves (usually in the range of **2 to 18 MHz**) that travel through the body and bounce back off of the internal organs and tissues.
- The returning echoes are captured by the ultrasound machine and used to create images of the internal structures.

Uses of Ultrasonography

Abdominal imaging:

Ultrasonography is used to image the organs of the abdomen, such as the liver, gallbladder, pancreas, spleen, and kidneys, to diagnose conditions such as liver disease, gallstones, pancreatitis, and kidney stones.

Musculoskeletal imaging:

Ultrasonography is used to image the muscles, tendons, and ligaments to diagnose conditions such as muscle strains, tendonitis, and ligament sprains.

Vascular imaging:

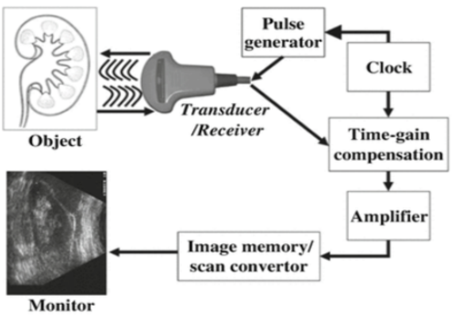
Ultrasonography is used to image blood vessels, such as the arteries and veins, to diagnose conditions such as blood clots, blockages, and aneurysms.

Eye and neck imaging:

Ultrasonography is used to image the eyes and neck to diagnose conditions such as cataracts, glaucoma, and thyroid nodules.

Emergency medicine: Ultrasonography is often used in emergency medicine to quickly and accurately diagnose conditions such as appendicitis, pneumothorax, and fluid buildup in the abdomen or chest.

Application 2:



Reception of echoes:
The transducer in the ultrasonography machine **receives the echoes and sends the information to a computer**, which processes the data to create images.

Image formation:
The computer uses the information from the echoes to **create images of the internal organs and tissues of the body**. The images are displayed on a screen, allowing the operator to see the structure and movement of the internal organs and tissues.

Transducer:
An ultrasonography machine consists of a transducer that is used to **emit and receive high-frequency sound waves**. The transducer is placed in direct contact with the skin or inserted into the body through a gel.

Emission of sound waves:
The transducer emits high-frequency sound waves (usually in the range of **2 to 18 MHz**) into the body. These sound waves travel through the body and encounter different tissues and organs, which have different acoustic properties.

Reflection of sound waves:
The sound waves encounter boundaries between different tissues and organs and bounce back, creating echoes. The strength of the echoes depends on the acoustic properties of the tissues and organs, such as density and stiffness