CYSF Logbook

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August

August 14, 2024

Today we began researching the basics for our science fair project, a noise cancelling device. We started learning about the concept of sound and how it works.

Further concepts that we need to understand include:

- Properties of sound waves
- How noise travels through different mediums
- Noise pollution
- Active noise cancellation
- Microphones & speakers

August 19, 2024

Today we aimed to expand our background knowledge on our device by researching materials that transmit and deflect sound. Our research concluded that sound transmits the fastest through solid mediums and slowest through gas mediums. Additionally, we explored the properties of various materials and the factors influencing sound transmission. A detailed summary of our research is provided below.

Materials That Transmit Sound

1. Solids:
   - Sound travels fastest through solids because the particles are closely packed together, which allows the vibrations to be transmitted more efficiently.
   - Examples: Metal, wood, glass, stone.
2. Liquids:
   - Sound travels slower in liquids compared to solids but faster than in gases.
   - Examples: Water, oil, alcohol.
3. Gases:
   - Sound travels slowest in gases because the particles are more spread out, making it harder for the vibrations to pass from one particle to another.
   - Examples: Air (the most common medium for sound), helium.

4. Vacuum

  - Sound cannot be heard in a vacuum (outer space) as there are no surrounding particles to transmit the vibrations.

Materials That Stop or Reduce Sound

Insulating Materials:

  - Certain materials are designed or naturally able to absorb sound waves, thereby reducing sound transmission. These materials are often used for soundproofing.
  - Examples:
    - Foams and Fibers: Acoustic foam, fiberglass insulation, mineral wool.
    - Dense Materials: Lead, heavy curtains, thick carpets.
    - Composite Materials: Soundproofing panels that combine different materials for enhanced sound absorption.

	Foams & Fiber	Dense Materials	Composite Materials
Difference	Lightweight, flexible,sound absorption and insulation	reflect sound, offering poor absorption but good soundproofing through mass	balance of sound absorption and reflection based on their composition.
Mechanism	porosity and air friction. sound waves enter the material then travel through air pockets or fiber which leads to them losing energy, converting sound energy into heat through friction and viscous effects	Non-porus, reflect, high density and rigidity cause sound waves to bounce off the surface rather than being absorbed, Dont absorb but its mass could block sound waves from passing through	Depends on how its structured—some composites have a layered structure where porous layers absorb sound, and dense layers that reflect.

Factors effecting absorption of sound	Porosity: Higher porosity increases sound absorption as more sound waves can enter and get trapped. Thickness: Thicker materials provide more space for sound waves to dissipate, improving absorption. Density: Optimal density is needed; too high can reduce porosity, too low may not absorb enough sound. Cell Size (Foams): Smaller cell sizes can trap sound waves more effectively, better absorbtion. Fiber Arrangement (Fibers): Randomly arranged fibers or those with a higher surface area can absorb more sound.	Density: Higher density=better sound reflection and less absorption. Surface Smoothness: Smoother surfaces reflect sound better, less absorbtion. Thickness: Thicker, dense materials block more sound by reflecting it Material Type: Diff materials have diff properties affecting sound reflection and absorption.	Material Composition: types of materials used (e.g., combination of porous and dense layers) affect the sound absorption properties. Layer Thickness: Thicker layers of absorptive materials= better sound absorption, while reflective layers= how much sound is blocked. Interface Quality: The quality of bonding between different layers can influence how sound waves are transmitted or absorbed at interfaces. Porosity & Density of Layers: the porosity and density of each layer in the composite impact sound absorption & reflection. Design and Structure: things like the arrangement and orientation of layers affect performance

Novel Material:

- Materials that possess exceptional mechanical, thermal, electrical, or chemical properties.

Absorption properties of materials

- High porosity
- Low to medium density
- Thick
- Irregular/uneven surface (diffusion)

Reflective properties of materials

- High density
- Stiff/Rigid
- Smooth surfaces

September

September 6, 2024

Today we researched the concept of speakers, including the different types, parts of a speaker and what they do. This can be seen below:

Speakers: Electrical signals flow through a coil of wire creating a temporary magnetic field. A permanent magnet surrounds the coil and it also has a magnetic field. As the two magnetic fields interact, it causes the coil to move back and forth, and because the voice coil is attached to a cone shaped diaphragm, it causes the cone to move/vibrate, and its movement pushes the air in front of it creating sound waves.

- Parts Of A Speaker:

    - Diaphragm/Cone: Moves back and forth to push air and create sound waves. The shape and material affect the sound quality and efficiency.
    - Dust Cap: Protects the voice coil from dust and debris, which can affect performance.
    - Voice Coil: Acts as an electromagnet that moves the cone in response to the electrical signal. The coil's movement generates sound waves by pushing and pulling the cone.
    - Magnet: Creates a steady magnetic field for the voice coil to interact with.
    - Spider: Supports the voice coil and keeps it centered in the magnetic gap while allowing it to move. It also controls the cone's motion and affects the speaker's resonance.
    - Basket: The structural frame that holds all the components together.
    - Suspension: A flexible ring that allows the cone to move freely while keeping it centered.

- **Types of Speakers:**
  - **Dynamic Speakers:** The most common type, using a diaphragm, voice coil, and magnet.
  - **Electrostatic Speakers:** uses a thin, electrically charged diaphragm between two stators. When audio signals create an electric field, the diaphragm moves and produces sound. They are known for high clarity and low distortion.
  - **Planar Magnetic Speakers:** Combine aspects of dynamic and electrostatic speakers, using a flat diaphragm and magnets.The diaphragm is placed between two sets of magnets. When an audio signal is passed through the conductive trace, it interacts with the magnetic field, causing the diaphragm to move and produce sound. Planar magnetic speakers are known for their high fidelity, low distortion, and wide soundstage.
  - **Horn Speakers:** Use a horn to amplify the sound, often used in professional audio setups.
  - **Subwoofers:** Designed to reproduce low-frequency sounds (bass, below 100Hz),Subwoofers often have large drivers and enclosures to handle and amplify low frequencies effectively.

- **Tweeters:** Designed to reproduce high-frequency sounds (treble).
- **Midrange Speakers:** Designed to reproduce mid-frequency sounds (between 500 Hz and 5000 Hz.
- **Full-range Speakers:** Capable of reproducing a wide range of frequencies (50 Hz to 20 kHz using a single driver).
- **Bone speaker**: Traditional speakers create sound by vibrating air molecules, producing pressure waves that the ear detects. In contrast, bone conduction speakers work by directly vibrating the bones of the skull, specifically the temporal bone. These vibrations are transmitted to the cochlea in the inner ear, allowing sound perception without involving the eardrum.

- **Power in Speakers**:
  - **Power Rating:** Indicates the amount of electrical power a speaker can handle, typically measured in watts (W).
  - **21 Watts:** A speaker rated at 21 watts can handle a continuous input power of 21 watts without being damaged.
  - **Peak vs. RMS:** Peak power is the maximum power a speaker can handle in short bursts, while RMS (Root Mean Square) is the continuous power rating.

September 10, 2024

Today we continued our research on speakers, covering the frequency range, efficiency, power of speakers, and what makes a good speaker.

- **Frequency Range**: 20Hz to 20kHz is the range of human hearing which most speakers produce
    - **Subwoofers:** Focus on low frequencies (below 100 Hz).
    - **Tweeters:** Focus on high frequencies (above 2 kHz).

- **Speaker Efficiency**: measured in decibels (dB), it indicates how loud a speaker will play for a given amount of power. Higher efficiency speakers need less power to achieve the same volume as lower efficiency speakers.

What Makes a Good Speaker:

- **Sound Quality:**
  - **Clarity:** Produces clear, distortion-free sound at all volume levels.
  - **Accuracy:** Reproduces audio as close to the original recording as possible.
  - **Balance:** Evenly handles low, mid, and high frequencies without any range overpowering the others.
- **Frequency responses:**
  - **Wide Range**: Capable of reproducing the full spectrum of human hearing (20 Hz to 20 kHz).
- **Sensitivity:**
  - **Efficiency**: Converts electrical power into sound effectively, measured in decibels (dB). Higher sensitivity means the speaker can produce more sound from less power.

- **Power Handling**:
  - **RMS and Peak Power:** Adequate power handling capabilities to ensure the speaker can perform well without damage at various volume levels.
  - **Dynamic Range:** Ability to handle both quiet and loud passages without distortion.
- **Distortion**:
  - **Low Distortion:** Maintains audio integrity even at high volumes, avoiding unwanted changes to the sound.
- **Impedance**:
  - **Compatibility:** Matches the amplifier's output to ensure efficient power transfer and optimal performance.

September 15, 2024

Today we researched about the concept of microphones, including each part and its function and the different types. The research is shown below.

Microphones: devices that convert sound into electrical signals. They capture audio by detecting sound waves, which cause a diaphragm inside the microphone to vibrate. These vibrations are then transformed into electrical signals that can be amplified, recorded, or transmitted.

- **Parts Of A Microphone**:
  - **Compensating Winding**: This is used to balance the inductance in the microphone's coil, improving the frequency response and ensuring a more accurate sound capture.

- **Diaphragm and Coil of Low Frequency System**: The diaphragm vibrates in response to sound waves, and the attached coil moves within a magnetic field to generate an electrical signal corresponding to low-frequency sounds.
- **Shock Mount**: This component isolates the microphone capsule from physical vibrations, reducing noise from handling or external vibrations.
- **Protective Cap and Mounting Plate of High Frequency System**: This cap protects the sensitive components of the high-frequency system while the mounting plate holds these components in place.
- **Mass Tube**: Adds mass to the microphone to stabilize the diaphragm and coil system, contributing to a controlled response to sound waves.

- **Central Screw**: Secures various parts of the microphone assembly together, ensuring structural integrity.
- **Cross-over Network**: This electronic circuit separates the audio signal into different frequency bands, directing low and high frequencies to the appropriate systems.
- **Bass Roll-Off Switch**: This switch allows the user to reduce the sensitivity of the microphone to low-frequency sounds, helping to minimize rumble and handling noise.
- **Rear Sound Openings, with Windscreen**: These openings allow sound to enter from the rear, contributing to the microphone's directional characteristics. The windscreen helps reduce wind noise and plosive sounds.
- **High Frequency System**: Captures and processes high-frequency sounds with its own diaphragm and related components, ensuring clarity in high-pitched audio.

- **Sintered Bronze Cap**: Protects the high-frequency diaphragm and coil while allowing sound to pass through. It also contributes to the overall durability and performance of the microphone.
- **Mounting Ring, Support for Cap**: Holds the protective cap in place, securing the components of the high-frequency system.
- **Low Frequency System**: Dedicated to capturing low-frequency sounds, ensuring that the microphone accurately reproduces bass tones.
- **Housing**: The outer casing that encloses and protects all the internal components of the microphone.

- Types of Microphones:
  - Dynamic Microphones: These are durable and versatile, ideal for live performances and general use. They work on the principle of electromagnetic induction.
  - Condenser Microphones: Known for their sensitivity and wide frequency response, these are often used in studio recordings. They require a power source, usually provided by batteries or phantom power.
  - Ribbon Microphones: These have a thin metal ribbon suspended in a magnetic field and are known for their vintage sound quality. They are more delicate than other types.
  - Lavalier Microphones: Small and clip-on, these are commonly used in television, theater, and public speaking.
  - Shotgun Microphones: These have a highly directional pickup pattern and are used in film and television production to capture sound from a specific direction.

November

November 20, 2024

We redid some of our initial research as we weren't consistent with our progress and forgot key concepts. Today, we focused on the basics of sound, the properties of sound waves, and the two different types of waves.

Basics of sound:

- <u>What is sound?</u>
  - Sound is a form of energy made by vibrations which can be transmitted through different surfaces and materials

- As something vibrates, the surrounding molecules vibrate as well, moving back and forth, bumping into other nearby molecules, causing them to vibrate as well. This movement keeps happening until the molecules reach a surface which either absorbs or blocks the vibrations. This movement is called sound waves.
- The lower the speed of vibrations, the lower the sound and vice versa.

- Properties of sound waves
  - **Frequency:** The number of vibrations a wave makes per second. It is measured in Hz and determines the pitch of a sound, higher frequencies mean higher pitch and lower frequencies mean lower pitch.
  - **Amplitude:** Amplitude is the height of a wave, the taller the wave the louder the sound.

    - **Wavelength** The distance between 2 points on a wave (from one crest to another.)
    - **Velocity:** The rate at which a sound wave travels through a medium.

- **How sound travels through different media (air, solids, liquids).**
    - **Air:** Sound waves travel slower since air is less dense (its particles are farther apart) meaning the particles have to move more in order to transfer energy.
    - **Solids:** The molecules vibrate quickly as they are tightly packed together causing them to interact with each other faster
    - **Water:** sound travels faster in water than air as the particles are closer together, allowing the vibrations to travel faster and farther
    - **Vacuum:** Sound cannot be heard in a vacume (outer space) as no surrounding particles transmit the vibrations.
- **Waves and Interference**
    - **Longitudinal waves:** when all the particles of a medium vibrate in the same direction as the wave

    - **Transverse waves:** This is where the displacement of the particles is perpendicular to the direction of the wave.
- **Constructive vs Destructive Interference**
    - **Constructive:** When two waves interfere with one another and create a larger wave than before
    - **Destructive:** When two waves interfere with one another and create no wave.. They destruct each other

December

December 1st, 2024

Today we bought the materials needed to create our device including the bone conduction speaker, microphones and amplifier.

Materials cost:
Bone-Conduction Speaker
$40
Enclosure Box
$20
Amplifier circuit
$40
Condenser Microphone
$20
Wire 5m
$10
Power supply
$25

February

February 15, 2025

Today we designed the layout of our device and how each part will be put together. The idea is that we will connect a condenser microphone to a amplifier that will also be connected to our bone speaker (along with a power source.) As the sound wave from the noise source travels through the wall/window, our condenser microphone attached to the surface detects the sound. This signal is then sent to the bone speaker, which generates and emits an inverse sound wave to cancel out the unwanted noise.

March & onwards

March 5 2025

Today, we started assembling our device and putting the components together. However, halfway through, we realized we had purchased the wrong amplifier circuit board and now have to order a new one. This delay is a major setback, especially with the deadline approaching and no data to analyze yet. It's making us recognize the need for better planning and attention to detail.

March 20, 2025

Today we finished up the method, and included all the background information/concepts and how the device works in detail. However we weren't able to finish creating our device due to inefficient time and incorrect amplifier circuit board. This led to our analysis and conclusion being incomplete. We plan to provide the analysis and connections to how our device can address of problem on our trifold.