ABSTRACT
Acoustical engineering is the branch of engineering dealing with sound and vibration. It is the application of acoustics, the science of sound and vibration, in technology. Acoustical engineers are typically concerned with the manipulation and control of sound. The primary goal of acoustical engineering is the reduction of unwanted sounds, which is referred to as noise control. Sound can have significant impacts on human health and well being, and is therefore important to control. Noise control principles are implemented into technology and design in a variety of ways. Applications include the design of noise barriers, sound absorbers, silencers, and buffer zones. The implementation of noise control technology differs in indoor and outdoor environments.

In addition to reducing unwanted sounds, acoustical engineers sometimes produce useful sounds or analyze sound waves to collect information. Examples of this include applications of ultrasonic and infrasonic, which make use of sound that cannot be heard by humans. Ultrasonic waves are acoustic waves with frequencies above the audible range (approximately 20 kHz). Applications of ultrasonic include sonar and medical imaging. Infrasonic waves are acoustic waves with frequencies below the audible range (approximately 20 Hz). Applications of infrasonic include the detection of earthquakes and volcanic eruptions [1]. Although acoustical engineering most commonly involves reducing noise, it also applies to these other important applications as well.

Keywords – Acoustical, Sound, Vibration, Absorbers, Silencers

I. ARCHITECTURAL ACOUSTICS

Fig1. Disney’s Concert Hall was meticulously designed for superior acoustical qualities.

Architectural acoustics refers to the control of sound and vibrations within buildings. Although architectural acoustics was first applied to opera houses and concert halls, this branch of acoustical engineering applies to any enclosed area, whether concert halls, office spaces, or ventilation ducts.

Reducing ventilation noise serves as another example of applied architectural acoustics. Many heating, ventilation, and air conditioning systems have silencers. Silencers can actively cancel noise by electronic feed forward and feedback techniques, or muffle the sound by either having sudden changes in cross section or walls with absorbent linings. Architectural acoustics involves the control of sound for ventilation, rooms, and anything else indoors.

II. ENVIRONMENTAL ACOUSTICS

Environmental acoustics are concerned with the control of sound and vibrations in an outdoor environment. This includes sounds generated by traffic, aircraft, industrial equipment, and anything else that might be considered a nuisance or a safety concern. Engineers concerned with environmental acoustics face the challenge of determining an acceptable level of noise and how noise can be controlled.
Fig2. At outdoor concerts like Woodstock, acoustic analysis is critical to creating the best experience for the audience and the performers.

Environmental noise control often involves the creation of noise barriers and use of buffer zones. An example of noise barriers are the walls built between highways and residential areas. Barriers are less effective in reducing high frequency noise due to the way sound diffracts around walls, but can reduce the overall loudness of traffic noise by as much as one half. Noise buffer zones are also an effective and simple method of noise control. Buffer zones group areas of high-level noise together and surround them with areas of lower-level noises. For example, an airport would not be surrounded immediately by residential properties, but rather by industrial and commercial properties. These two methods are perhaps the most common examples of outdoor noise control.

III. SOUND BAFFLE
A sound baffle is a construction or device which reduces the strength (level) of airborne sound. Sound baffles are a fundamental tool of noise mitigation, the practice of minimizing noise pollution or reverberation. An important type of sound baffle is the noise barrier constructed along highways to reduce sound levels at properties in the vicinity. Sound baffles are also applied to walls and ceilings in building interiors to absorb sound energy and thus lessen reverberation.

IV. SOUND REINFORCEMENT SYSTEM
A sound reinforcement system is the combination of microphones, signal processors, amplifiers, and loudspeakers that makes live or pre-recorded sounds louder and may also distribute those sounds to a larger or more distant audience [2].

In some situations, a sound reinforcement system is also used to enhance the sound of the sources on the stage, as opposed to simply amplifying the sources unaltered. A sound reinforcement system may be very complex, including hundreds of microphones, complex audio mixing and signal processing systems, tens of thousands of watts of amplification, and multiple loudspeaker arrays, all overseen by a team of audio engineers and technicians. On the other hand, a sound reinforcement system can be as simple as a small public address (PA) system in a coffeehouse, consisting of a single microphone connected to a loudspeaker. In both cases, these systems reinforce sound to make it louder or distribute it to a wider audience [3].

Some audio engineers and others in the professional audio industry disagree over whether these audio systems should be called sound reinforcement (SR) systems or PA systems. Distinguishing between the two terms by technology and capability is common, while others distinguish by intended use (e.g., SR systems are for live event support and PA systems are for reproduction of speech and recorded music in buildings and institutions). In some regions or markets, the distinction between the two terms is important, though the terms are considered interchangeable in many professional circles [4].

A. Basic Concept
A typical sound reinforcement system consists of: input transducers (e.g., microphones), which convert sound energy into an electric signal, signal processors which alter the signal characteristics, amplifiers, which add power to the signal without otherwise changing its content, and output transducers (e.g., loudspeakers), which convert the signal back into sound energy. These primary parts involve varying amounts of individual components [5] to achieve the desired goal of
reinforcing and clarifying the sound to the audience, performers, or other individuals.

B. Applications
Sound reinforcement systems are used in a broad range of different settings, each of which poses different challenges.

C. Rental Systems
Audio visual (AV) rental systems have to be able to withstand heavy use, and even abuse from renters. For this reason, rental companies tend to own speaker cabinets which are heavily braced and protected with steel corners, and electronic equipment such as power amplifiers or effects are often mounted into protective road cases. As well, rental companies tend to select gear which has electronic protection features, such as speaker-protection circuitry and amplifier limiters.

As well, rental systems for non-professionals need to be easy to use and set up, and they must be easy to repair and maintain for the renting company. From this perspective, speaker cabinets need to have easy-to-access horns, speakers, and crossover circuitry, so that repairs or replacements can be made. Some rental companies often rent powered amplifier-mixers, mixers with onboard effects, and powered subwoofers for use by non-professionals, which are easier to set up and use.

D. Live Music Clubs
Setting up sound reinforcement [6] for live music clubs often poses unique challenges, because there is such a large variety of venues which are used as clubs, ranging from former warehouses or music theaters to small restaurants or basement pubs with concrete walls. In some cases, clubs are housed in multi-story venues with balconies or in "L"-shaped rooms, which makes it hard to get a consistent sound for all audience members. The solution is to use fill-in speakers to obtain good coverage, using a delay to ensure that the audience does not hear the same sound at different times.

E. Church Sound
Designing systems in churches and similar religious facilities often poses a challenge, because the speakers may have to be unobtrusive to blend in with antique woodwork and stonework. In some cases, audio designers have designed custom-painted speaker cabinets so that the speakers will blend in with the church architecture. Some church facilities, such as sanctuaries or chapels are long rooms with low ceilings, which mean that additional fill-in speakers are needed throughout the room to give good coverage. An additional challenge with church SR systems is that, once installed, they are often operated by amateur volunteers from the congregation, which means that they must be easy to run and troubleshoot.

F. Touring Systems
Touring sound systems have to be powerful and versatile enough to cover many different rooms, often being of many different sizes and shapes. They also need to use "field-replaceable" components such as speakers, horns, and fuses, which are easily accessible for repairs during a tour. Tour sound systems are often designed with substantial redundancy features, so that in the event of equipment failure or amplifier overheating, the system will continue to function. Touring systems for acts performing for crowds of a few thousand people and up are typically set up and operated by a team of technicians and engineers that travel with the talent to every show.
G. Live Theater
Sound for live theater, operatic theater, and other dramatic applications may pose problems similar to those of churches, in cases where a theater is an old heritage building where speakers and wiring may have to blend in with woodwork. The need for clear sight lines in some theaters may make the use of regular speaker cabinets unacceptable; instead, slim, low-profile speakers are often used instead.
In live theater and drama, performers move around onstage, which means that wireless microphones may have to be used. Wireless microphones need to be set up and maintained properly, to avoid interference and reception problems.
H. Classical Music and Opera
A subtle type of sound reinforcement called acoustic enhancement is used in some concert halls where classical music such as symphonies and opera is performed. Acoustic enhancement systems help give a more even sound in the hall and prevent "dead spots" in the audience seating area by "...augmenting a hall's intrinsic acoustic characteristics." The systems use "...an array of microphones connected to a computer [which is] connected to an array of loudspeakers." However, as concertgoers have become aware of the use of these systems, debates have arisen, because "...purists maintain that the natural acoustic sound of [Classical] voices [or] instruments in a given hall should not be altered."

I. Lecture Halls and Conference Rooms
Lecture halls and conference rooms pose the challenge of reproducing speech clearly to a large hall, which may have reflective, echo-producing surfaces. In some conferences, sound engineers have to provide microphones for a large number of people, in the case of a panel conference or debate. In some cases, automatic mixers are used to control the levels of the microphones.

J. Sports Sound Systems
Systems for outdoor sports facilities and ice rinks often have to deal with substantial echo, which can make speech unintelligible. Sports and recreational sound systems often face environmental challenges as well, such as the need for weather-proof outdoor speakers in outdoor stadiums and humidity- and splash-resistant speakers in swimming pools.

V. SOUNDPROOFING

![An anechoic chamber, showing acoustic damping tiles used for sound absorption.](image)

![Sound reflection board](image)

Soundproofing is any means of reducing the sound pressure with respect to a specified sound source and receptor. There are several basic approaches to reducing sound: increasing the distance between source and receiver, using noise barriers to reflect or absorb the energy of the sound waves, using damping structures such as sound baffles, or using active anti noise sound generators.

Two distinct soundproofing problems may need to be considered when designing acoustic treatments - to improve the sound within a room (See anechoic chamber), and reduce sound leakage to/from adjacent rooms or outdoors. Acoustic quieting, noise mitigation, and noise control can be used to limit unwanted noise. Soundproofing can suppress unwanted indirect sound waves such as reflections that cause echoes and resonances that cause reverberation. Soundproofing can reduce the transmission of unwanted direct sound waves from the source to an involuntary listener through the use of distance and intervening objects in the sound path.

A. Damping
Damping means to reduce resonance in the room, by absorption or redirection (reflection or diffusion). Absorption will reduce the overall sound level, whereas redirection makes unwanted sound harmless or even beneficial by reducing coherence. Damping can reduce
the acoustic resonance in the air, or mechanical resonance in the structure of the room itself or things in the room.

B. Absorption
Absorbing sound spontaneously converts part of the sound energy to a very small amount of heat in the intervening object (the absorbing material), rather than sound being transmitted or reflected. There are several ways in which a material can absorb sound. The choice of sound absorbing material will be determined by the frequency distribution of noise to be absorbed and the acoustic absorption profile required.

α. Porous absorbers:
Porous absorbers, typically open cell rubber foams or melamine sponges, absorb noise by friction within the cell structure. Porous open cell foams are highly effective noise absorbers across a broad range of medium-high frequencies. Performance is less impressive at low frequencies.

β. Resonant absorbers:
Resonant panels, Helmholtz resonators and other resonant absorbers work by damping a sound wave as they reflect it. Unlike porous absorbers, resonant absorbers are most effective at low-medium frequencies and the absorption of resonant absorbers is always matched to a narrow frequency range.

C. Reflection
In an outdoor environment such as highway engineering, embankments or paneling are often used to reflect sound upwards into the sky.

D. Diffusion
If a specular reflection from a hard flat surface is giving a problematic echo then an acoustic diffuser may be applied to the surface. It will scatter sound in all directions.

E. Residential Soundproofing
Residential soundproofing aims to decrease or eliminate the effects of exterior noise. The main focus of residential soundproofing in existing structures is the windows. Curtains can be used to damp sound either through use of heavy materials or through the use of air chambers known as honeycombs. Single-, double- and triple-honeycomb designs achieve relatively greater degrees of sound damping. The primary soundproofing limit of curtains is the lack of a seal at the edge of the curtain. Double-pane windows achieve somewhat greater sound damping than single-pane windows. Significant noise reduction can be achieved by installing a second interior window. In this case the exterior window remains in place while a slider or hung window is installed within the same wall openings.

VI. REFERENCES