# Module 1: Basic Acoustics and Sound Theory

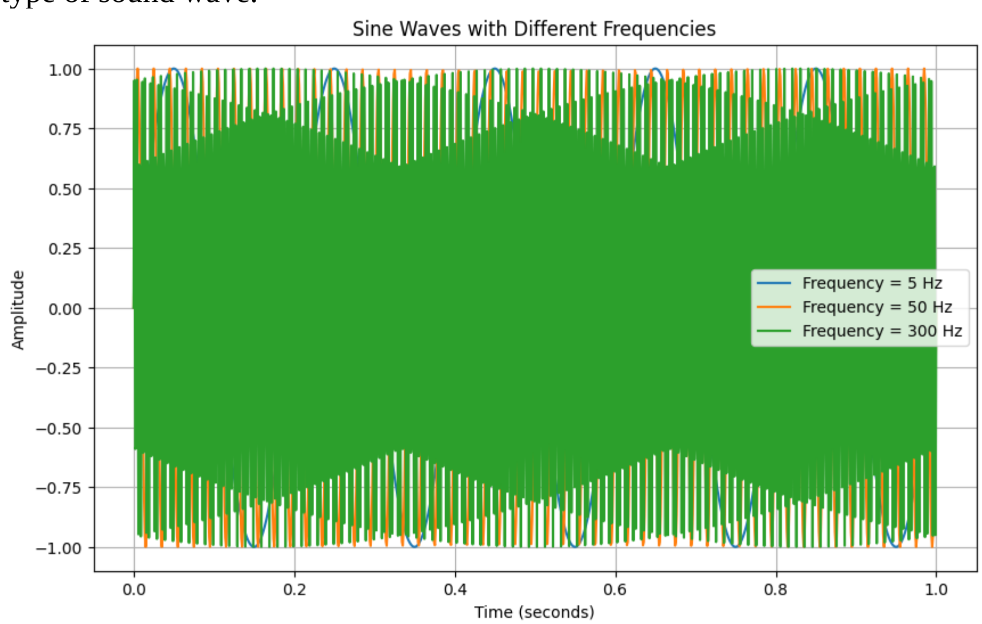
This module is foundational for students studying audio engineering, focusing on the basic properties of sound and how it is manipulated and processed both in analog and digital formats. Here, we'll delve into the fundamentals of sound, covering the nature of sound waves, human hearing, and the basics of audio signal flow.

## ➢ Fundamentals of Sound

1. **Sound Waves: Frequency, Amplitude, Wavelength, and Velocity**

   - **Sound Waves**: Vibrations that travel through the air or another medium and can be heard when they reach a person's or animal's ear.
   - **Frequency**: The number of complete wave cycles per second, measured in Hertz (Hz). It determines the pitch of the sound.
   - **Amplitude**: The height of the wave, which determines the loudness or volume.
   - **Wavelength**: The distance between corresponding points of two consecutive waves.
   - **Velocity**: The speed at which the sound wave travels through a medium, typically about 343 meters per second in air at room temperature.

2. **Visual Representation of Sound Waves**
   To illustrate these concepts, we can use Python to plot a simple sine wave, which is a basic type of sound wave.



```python
import numpy as np
import matplotlib.pyplot as plt

# Parameters for different waves
frequencies = [5, 10, 20]  # frequencies of the waves in Hz
amplitude = 1  # amplitude of the waves
time = np.linspace(0, 1, 1000)  # time vector

# Create sine waves with different frequencies
waves = [amplitude * np.sin(2 * np.pi * f * time) for f in frequencies]

# Plotting the waves
plt.figure(figsize=(10, 6))
for i, wave in enumerate(waves):
   plt.plot(time, wave, label=f'Frequency = {frequencies[i]} Hz')

plt.title('Sine Waves with Different Frequencies')
plt.xlabel('Time (seconds)')
plt.ylabel('Amplitude')
plt.grid(True)
plt.legend()
plt.show()
```

## 3. The Human Hearing Range and Perception of Sound

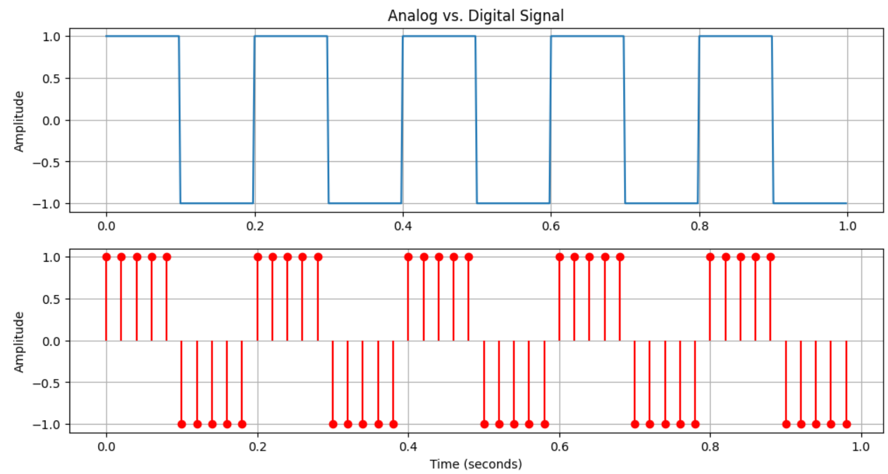
Humans can typically hear frequencies from about 20 Hz to 20,000 Hz. The sensitivity to different frequencies varies by age and individual. Sounds outside this range exist (infrasound and ultrasound) but are not audible to humans.

## 4. Audio Signal Flow

Understanding how audio signals flow from source to output is crucial in audio engineering.

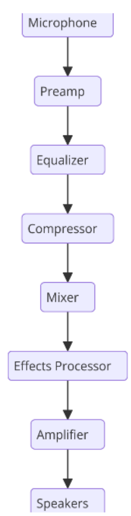
- **Analog vs. Digital Signals**
  - **Analog Signals**: Continuous signals that vary over time and are susceptible to degradation and noise.
  - **Digital Signals**: Represent signals in discrete values (0s and 1s), offering easier

```
from scipy.signal import square

# Generate a square wave (analog)
t = np.linspace(0, 1, 500, endpoint=False)
analog_signal = square(2 * np.pi * 5 * t)

# Sampling the analog signal to convert it to a digital signal
sampling_rate = 50  # 50 samples per second
samples = np.arange(0, 500, 500 // sampling_rate)
digital_signal = analog_signal[samples]

# Plotting both signals
plt.figure(figsize=(12, 6))
plt.subplot(211)
plt.plot(t, analog_signal, label='Analog Signal')
plt.title('Analog vs. Digital Signal')
plt.ylabel('Amplitude')
plt.grid(True)

plt.subplot(212)
plt.stem(samples / 500, digital_signal, 'r', markerfmt='ro', basefmt=" ",
use_line_collection=True, label='Digital Signal')
plt.xlabel('Time (seconds)')
plt.ylabel('Amplitude')
plt.grid(True)
plt.show()
```

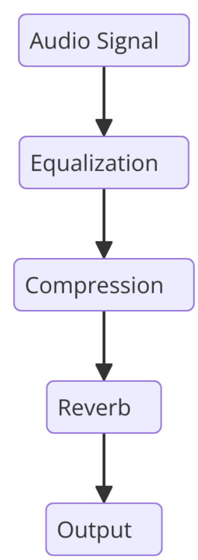



5. **<u>Signal Chain and Signal Processing</u>**

- **Signal Chain**: The path an audio signal takes from the source (microphone) through various processing stages (mixer, amplifier) to the output (speakers).
- **Signal Processing**: The manipulation of these signals to improve quality or alter them creatively. This can include equalization, compression, and reverb.




**Signal Chain**




**Signal Processing**