# Question 2 Task B

Report

## 1 Introduction

Music is a complex auditory signal characterized by variations in pitch, timbre, and rhythm. Different genres of music have unique spectral and temporal properties that can be analyzed using spectrograms. A spectrogram represents the frequency content of a signal over time, making it a powerful tool for visualizing musical features. By comparing spectrograms across genres, we can identify distinct patterns in energy distribution, frequency composition, and rhythmic structures.

This study examines the spectrograms of four songs, each belonging to a different genre: Classical, Rock, EDM, and Pop. Using the Hanning windowing technique, we analyze how the spectral content varies across these genres. The findings contribute to a better understanding of genre-specific characteristics and their implications for music classification and processing.

## 2 Methodology

Spectrograms were generated using Short-Time Fourier Transform (STFT) with the Hanning windowing technique. The analysis was performed using the following parameters:

- Window Type: Hanning
- FFT Size: 2048
- Hop Length: 512
- Frequency Scale: Logarithmic

## 3 Spectrogram Analysis

### 3.1 Classical - *Clair de Lune* (Claude Debussy)

Classical music is characterized by smooth transitions and sustained harmonic structures. The spectrogram of *Clair de Lune* reveals a well-distributed energy concentration in the mid-frequency range. The slow, flowing nature of the piece results in long, continuous spectral components with minimal transient peaks. The lack of percussive elements ensures a smooth time-frequency representation.

### 3.2 Rock - *Bohemian Rhapsody* (Queen)

Rock music, such as *Bohemian Rhapsody*, exhibits a broad spectral range with prominent mid-to-high frequency energy. The presence of electric guitars and drums creates sharp transient peaks, particularly during percussion strikes. The vocals introduce sustained harmonic structures interspersed with dynamic changes, leading to significant variations in energy distribution. The spectrogram reveals multiple frequency bands active simultaneously, reflecting the complexity of rock compositions.

### 3.3 EDM - *Strobe* (Deadmau5)

EDM (Electronic Dance Music) features a strong low-frequency presence due to its heavy bass elements. The spectrogram of *Strobe* highlights rhythmic, pulsating patterns with periodic bursts of energy in the low and mid frequencies. The synthesized elements contribute to sharp, well-defined frequency bands. The use of effects like sidechain compression is visible as periodic dips in amplitude, creating a characteristic EDM pumping effect.

### 3.4 Pop - *Blinding Lights* (The Weeknd)

Pop music typically maintains a balanced distribution across frequency bands. The spectrogram of *Blinding Lights* showcases clear vocal lines with steady rhythmic backing. The beat structure is consistent, with regular transient peaks from percussive elements. Synthesizers and layered harmonics contribute to a smooth and well-defined spectrogram, making the genre appealing to a broad audience.

## 4 Comparative Analysis

- **Energy Distribution:** Classical music has a smooth energy distribution, while EDM and Rock show high-energy bursts.
- **Frequency Content:** EDM is bass-heavy, Classical is mid-range dominant, and Rock and Pop spread across mid-to-high frequencies.
- **Rhythmic Variations:** Rock and EDM exhibit clear transient peaks, while Classical remains continuous.
- **Windowing Effects:** Hanning and Hamming provide smooth transitions, whereas the Rectangular window introduces spectral leakage, particularly in Pop and EDM.

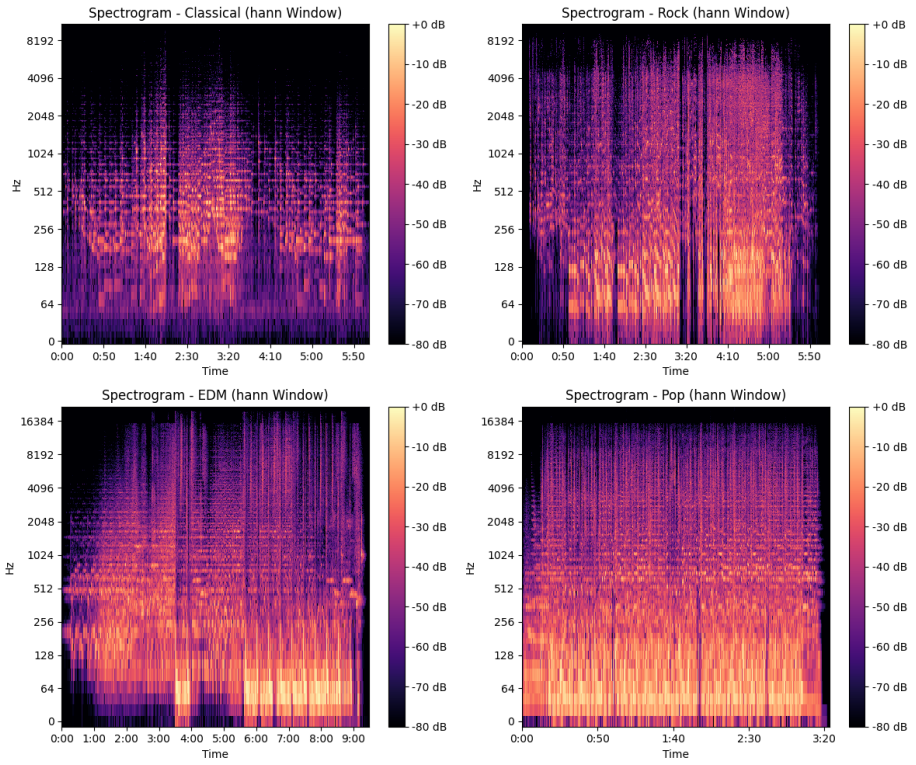


Figure 1: Spectogram

# 5 Conclusion

This study provides a comprehensive analysis of spectrograms across four different music genres, highlighting their unique spectral and rhythmic properties. Classical music exhibits smooth harmonic transitions with minimal transients, making it distinctly different from Rock and EDM, which show high-energy bursts and rhythmic variations. Rock music features a broad spectral range, with dynamic shifts in energy due to instrumental complexity. EDM is dominated by low-frequency content and periodic pulses, creating a structured rhythmic profile. Pop music maintains a balanced frequency distribution with clear vocal presence and steady beats, making it an accessible and commercially viable genre.

The use of the Hanning window has provided smooth spectral representations, minimizing spectral leakage while preserving important musical characteristics. The clarity of frequency components in the spectrograms ensures accurate genre analysis, making it a preferred choice for spectrogram generation. Future work can extend this study by incorporating machine learning models to automate genre identification based on spectral features. Colab File