In [1]:
```
!pip install matplotlib librosa IPython
```

```
Requirement already satisfied: matplotlib in c:\users\hp\anaconda3\lib\site-packages (3.7.2)
Requirement already satisfied: librosa in c:\users\hp\anaconda3\lib\site-packages (0.10.2.post1)
Requirement already satisfied: IPython in c:\users\hp\anaconda3\lib\site-packages (8.15.0)
Requirement already satisfied: contourpy>=1.0.1 in c:\users\hp\anaconda3\lib\site-packages (from matplotlib) (1.0.5)
Requirement already satisfied: cycler>=0.10 in c:\users\hp\anaconda3\lib\site-packages (from matplotlib) (0.11.0)
Requirement already satisfied: fonttools>=4.22.0 in c:\users\hp\anaconda3\lib\site-packages (from matplotlib) (4.55.0)
Requirement already satisfied: kiwisolver>=1.0.1 in c:\users\hp\anaconda3\lib\site-packages (from matplotlib) (1.4.4)
Requirement already satisfied: numpy>=1.20 in c:\users\hp\anaconda3\lib\site-packages (from matplotlib) (1.24.3)
Requirement already satisfied: packaging>=20.0 in c:\users\hp\anaconda3\lib\site-packages (from matplotlib) (23.2)
Requirement already satisfied: pillow>=6.2.0 in c:\users\hp\anaconda3\lib\site-packages (from matplotlib) (9.4.0)
Requirement already satisfied: pyparsing<3.1,>=2.3.1 in c:\users\hp\anaconda3\lib\site-packages (from matplotlib) (3.0.9)
Requirement already satisfied: python-dateutil>=2.7 in c:\users\hp\anaconda3\lib\site-packages (from matplotlib) (2.8.2)
Requirement already satisfied: audioread>=2.1.9 in c:\users\hp\anaconda3\lib\site-packages (from librosa) (3.0.1)
Requirement already satisfied: scipy>=1.2.0 in c:\users\hp\anaconda3\lib\site-packages (from librosa) (1.11.1)
Requirement already satisfied: scikit-learn>=0.20.0 in c:\users\hp\anaconda3\lib\site-packages (from librosa) (1.3.0)
Requirement already satisfied: joblib>=0.14 in c:\users\hp\anaconda3\lib\site-packages (from librosa) (1.2.0)
Requirement already satisfied: decorator>=4.3.0 in c:\users\hp\anaconda3\lib\site-packages (from librosa) (5.1.1)
Requirement already satisfied: numba>=0.51.0 in c:\users\hp\anaconda3\lib\site-packages (from librosa) (0.57.1)
Requirement already satisfied: soundfile>=0.12.1 in c:\users\hp\anaconda3\lib\site-packages (from librosa) (0.12.1)
Requirement already satisfied: pooch>=1.1 in c:\users\hp\anaconda3\lib\site-packages (from librosa) (1.8.2)
Requirement already satisfied: soxr>=0.3.2 in c:\users\hp\anaconda3\lib\site-packages (from librosa) (0.5.0.post1)
Requirement already satisfied: typing-extensions>=4.1.1 in c:\users\hp\anaconda3\lib\site-packages (from librosa) (4.12.2)
Requirement already satisfied: lazy-loader>=0.1 in c:\users\hp\anaconda3\lib\site-packages (from librosa) (0.2)
Requirement already satisfied: msgpack>=1.0 in c:\users\hp\anaconda3\lib\site-packages (from librosa) (1.0.3)
Requirement already satisfied: backcall in c:\users\hp\anaconda3\lib\site-packages (from IPython) (0.2.0)
Requirement already satisfied: jedi>=0.16 in c:\users\hp\anaconda3\lib\site-packages (from IPython) (0.18.1)
Requirement already satisfied: matplotlib-inline in c:\users\hp\anaconda3\lib\site-packages (from IPython) (0.1.6)
Requirement already satisfied: pickleshare in c:\users\hp\anaconda3\lib\site-packages (from IPython) (0.7.5)
Requirement already satisfied: prompt-toolkit!=3.0.37,<3.1.0,>=3.0.30 in c:\users\hp\anaconda3\lib\site-packages (from IPython) (3.0.36)
Requirement already satisfied: pygments>=2.4.0 in c:\users\hp\anaconda3\lib\site-packages (from IPython) (2.15.1)
Requirement already satisfied: stack-data in c:\users\hp\anaconda3\lib\site-packages (from IPython) (0.2.0)
Requirement already satisfied: traitlets>=5 in c:\users\hp\anaconda3\lib\site-packages (from IPython) (5.7.1)
Requirement already satisfied: colorama in c:\users\hp\anaconda3\lib\site-packages (from IPython) (0.4.6)
Requirement already satisfied: parso<0.9.0,>=0.8.0 in c:\users\hp\anaconda3\lib\site-packages (from jedi>=0.16->IPython) (0.8.3)
Requirement already satisfied: llvmlite<0.41,>=0.40.0dev0 in c:\users\hp\anaconda3\lib\site-packages (from numba>=0.51.0->librosa) (0.40.0)
Requirement already satisfied: platformdirs>=2.5.0 in c:\users\hp\anaconda3\lib\site-packages (from pooch>=1.1->librosa) (3.10.0)
Requirement already satisfied: requests>=2.19.0 in c:\users\hp\anaconda3\lib\site-packages (from pooch>=1.1->librosa) (2.32.3)
Requirement already satisfied: wcwidth in c:\users\hp\anaconda3\lib\site-packages (from prompt-toolkit!=3.0.37,<3.1.0,>=3.0.30->IPython) (0.2.13)
Requirement already satisfied: six>=1.5 in c:\users\hp\anaconda3\lib\site-packages (from python-dateutil>=2.7->matplotlib) (1.16.0)
Requirement already satisfied: threadpoolctl>=2.0.0 in c:\users\hp\anaconda3\lib\site-packages (from scikit-learn>=0.20.0->librosa) (2.2.0)
Requirement already satisfied: cffi>=1.0 in c:\users\hp\anaconda3\lib\site-packages (from soundfile>=0.12.1->librosa) (1.15.1)
Requirement already satisfied: executing in c:\users\hp\anaconda3\lib\site-packages (from stack-data->IPython) (0.8.3)
Requirement already satisfied: asttokens in c:\users\hp\anaconda3\lib\site-packages (from stack-data->IPython) (2.0.5)
Requirement already satisfied: pure-eval in c:\users\hp\anaconda3\lib\site-packages (from stack-data->IPython) (0.2.2)
Requirement already satisfied: pycparser in c:\users\hp\anaconda3\lib\site-packages (from cffi>=1.0->soundfile>=0.12.1->librosa) (2.21)
Requirement already satisfied: charset-normalizer<4,>=2 in c:\users\hp\anaconda3\lib\site-packages (from requests>=2.19.0->pooch>=1.1->librosa)
(2.0.4)
Requirement already satisfied: idna<4,>=2.5 in c:\users\hp\anaconda3\lib\site-packages (from requests>=2.19.0->pooch>=1.1->librosa) (3.10)
Requirement already satisfied: urllib3<3,>=1.21.1 in c:\users\hp\anaconda3\lib\site-packages (from requests>=2.19.0->pooch>=1.1->librosa) (2.2.3)
Requirement already satisfied: certifi>=2017.4.17 in c:\users\hp\anaconda3\lib\site-packages (from requests>=2.19.0->pooch>=1.1->librosa) (2024.8.30)
```

In [1]:
```
import os
import matplotlib.pyplot as plt
import librosa, librosa.display
import IPython.display as ipd
```

In [3]:
```
BASE_FOLDER = "E:\Github\Machine_Learning\AudioSignalProcessingForML_Valerio_Valerado\\audio_resources"
violin_sound_file = "violin_c.wav"
piano_sound_file = "piano_c.wav"
tremolo_sound_file = "tremolo.wav"
```

In [4]:
```
print(os.path.join(BASE_FOLDER, violin_sound_file))
```

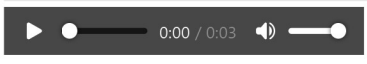
```
E:\Github\Machine_Learning\AudioSignalProcessingForML_Valerio_Valerado\audio_resources\violin_c.wav
```

In [5]:
```
# load sounds
violin_c4, _ = librosa.load(os.path.join(BASE_FOLDER, violin_sound_file))
piano_c5, _ = librosa.load(os.path.join(BASE_FOLDER, piano_sound_file))
```

In [6]:
```
def plot_spectrogram(signal, name):
    """Compute power spectrogram with Short-Time Fourier Transform and plot result."""
    spectrogram = librosa.amplitude_to_db(librosa.stft(signal))
    plt.figure(figsize=(20, 15))
    librosa.display.specshow(spectrogram, y_axis="log")
    plt.colorbar(format="%+2.0f dB")
    plt.title(f"Log-frequency power spectrogram for {name}")
    plt.xlabel("Time")
    plt.show()
```

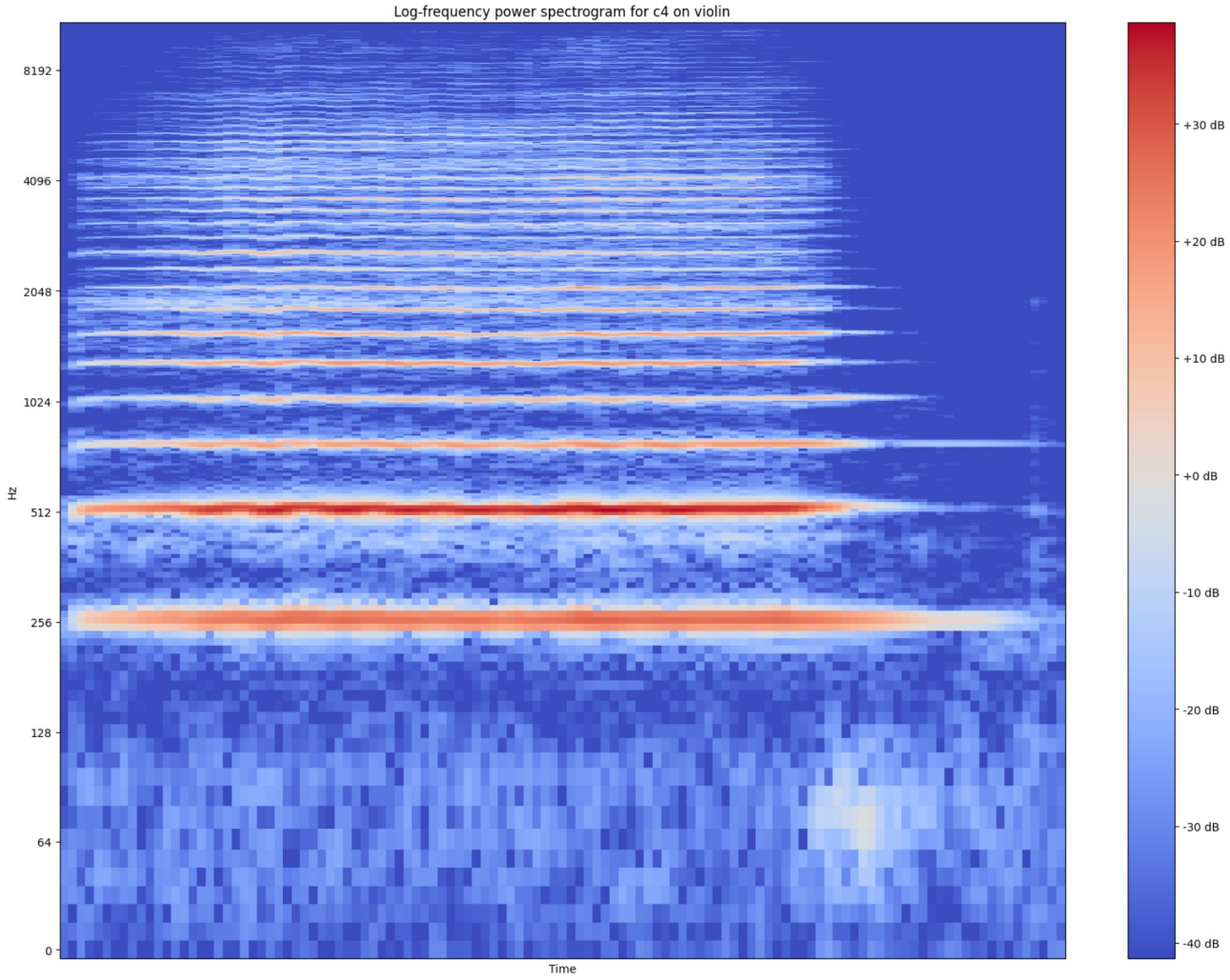
In [7]:
```
ipd.Audio(os.path.join(BASE_FOLDER, violin_sound_file))
```

Out[7]:



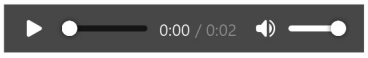
In [8]:
```
plot_spectrogram(violin_c4, "c4 on violin")
```

```
C:\Users\hp\AppData\Local\Temp\ipykernel_2888\2912319097.py:3: UserWarning: amplitude_to_db was called on complex input so phase information will be d
iscarded. To suppress this warning, call amplitude_to_db(np.abs(S)) instead.
  spectrogram = librosa.amplitude_to_db(librosa.stft(signal))
```



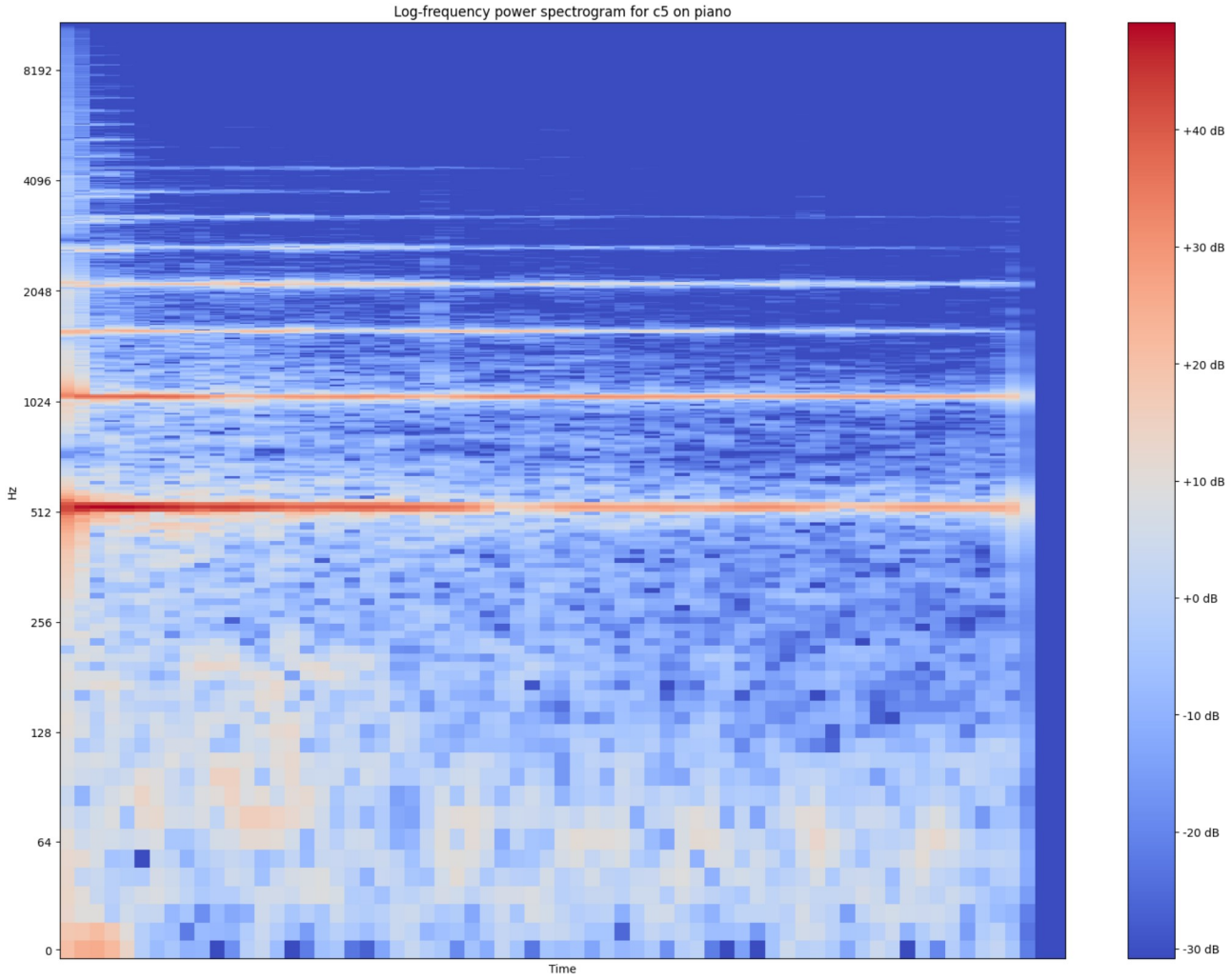
In [9]:
```
ipd.Audio(os.path.join(BASE_FOLDER, piano_sound_file))
```

Out[9]:



In [10]:
```
plot_spectrogram(piano_c5, "c5 on piano")
```

```
C:\Users\hp\AppData\Local\Temp\ipykernel_2888\2912319097.py:3: UserWarning: amplitude_to_db was called on complex input so phase information will be d
iscarded. To suppress this warning, call amplitude_to_db(np.abs(S)) instead.
  spectrogram = librosa.amplitude_to_db(librosa.stft(signal))
```



In [11]:
```
ipd.Audio(os.path.join(BASE_FOLDER, tremolo_sound_file))
```

Out[11]:

0:00 / 0:14

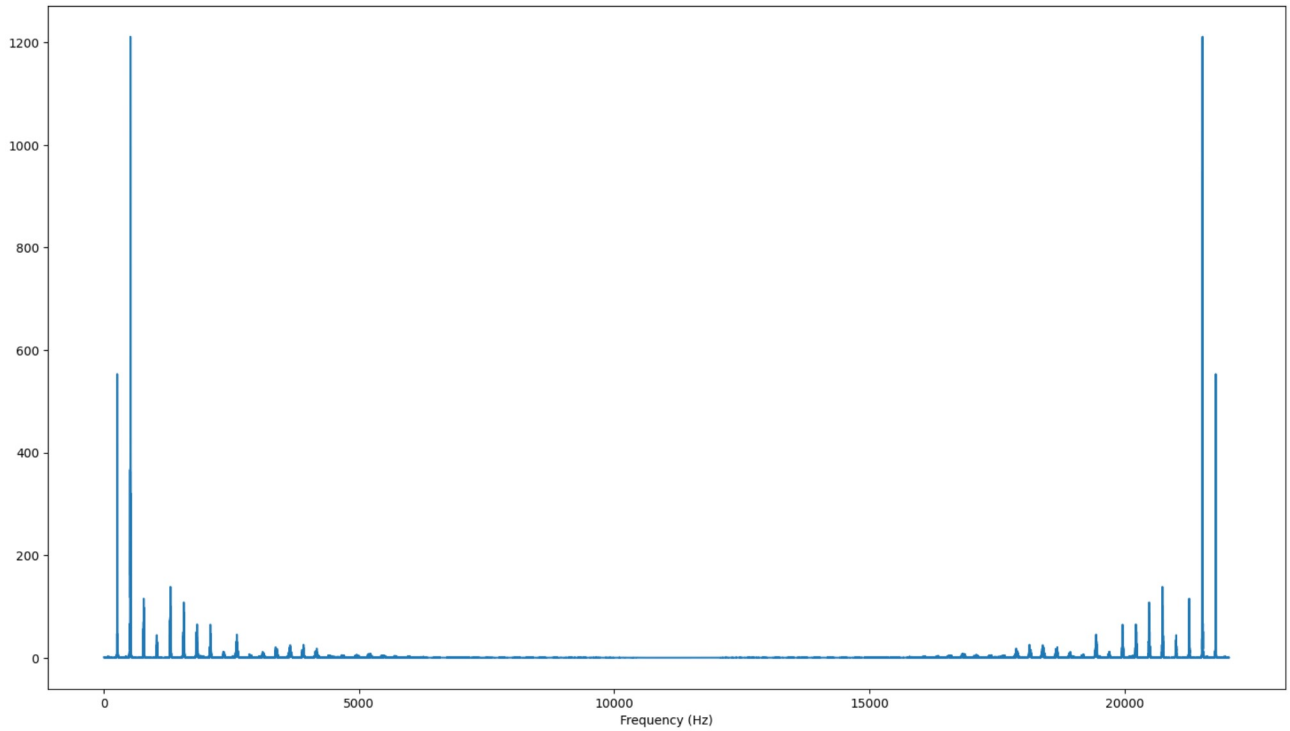
In [12]:
```
import numpy as np
```

In [13]:
```
X = np.fft.fft(violin_c4)
```

In [14]:
```
X_mag = np.absolute(X)
f = np.linspace(0, _, len(X_mag))
```

In [15]:
```
plt.figure(figsize=(18, 10))
plt.plot(f, X_mag) # magnitude spectrum
plt.xlabel('Frequency (Hz)')
```

Out[15]:
```
Text(0.5, 0, 'Frequency (Hz)')
```



In [16]:
```
len(violin_c4)
```

Out[16]:
```
59772
```

In [ ]: