Load the file: EEG-2.mat

In [ ]:
```
from scipy.io import loadmat
import matplotlib.pyplot as plt
import numpy as np
from scipy.signal import spectrogram
```

In [ ]:
```
data = loadmat('EEG-2.mat')
EEG  = data['EEG'].reshape(-1) # Extract the EEG variable
t = data['t'][0]             # ... and the t variablea
```

1 i. What is the sampling interval?

In [ ]:
```
dt = t[1] - t[0]
print('The sampling interval is', dt)
```

```
The sampling interval is 0.001
```

1 ii. What is the total duration of the recording (T)

In [ ]:
```
#sampling frequency
f0 = 1/dt

#number of points in the data (N)
N = np.size(EEG)

# What is the total time of the observation (T)?
T = N * dt
print('The total duration of the recording is', T, 'second')
```

```
The total duration of the recording is 1.0 second
```

1 iii. What is the frequency resolution (df)?

1 iv. What is the nyquist frequency (fNQ)?

In [ ]:
```
fNQ = f0/2
df = 1/T

print('The Nyquist frequency is', fNQ)
print('The frequency resolution is', df)
```

```
The Nyquist frequency is 500.0
The frequency resolution is 1.0
```

v. Plot the data and visually inspect it. Describe briefly (in a sentence or two

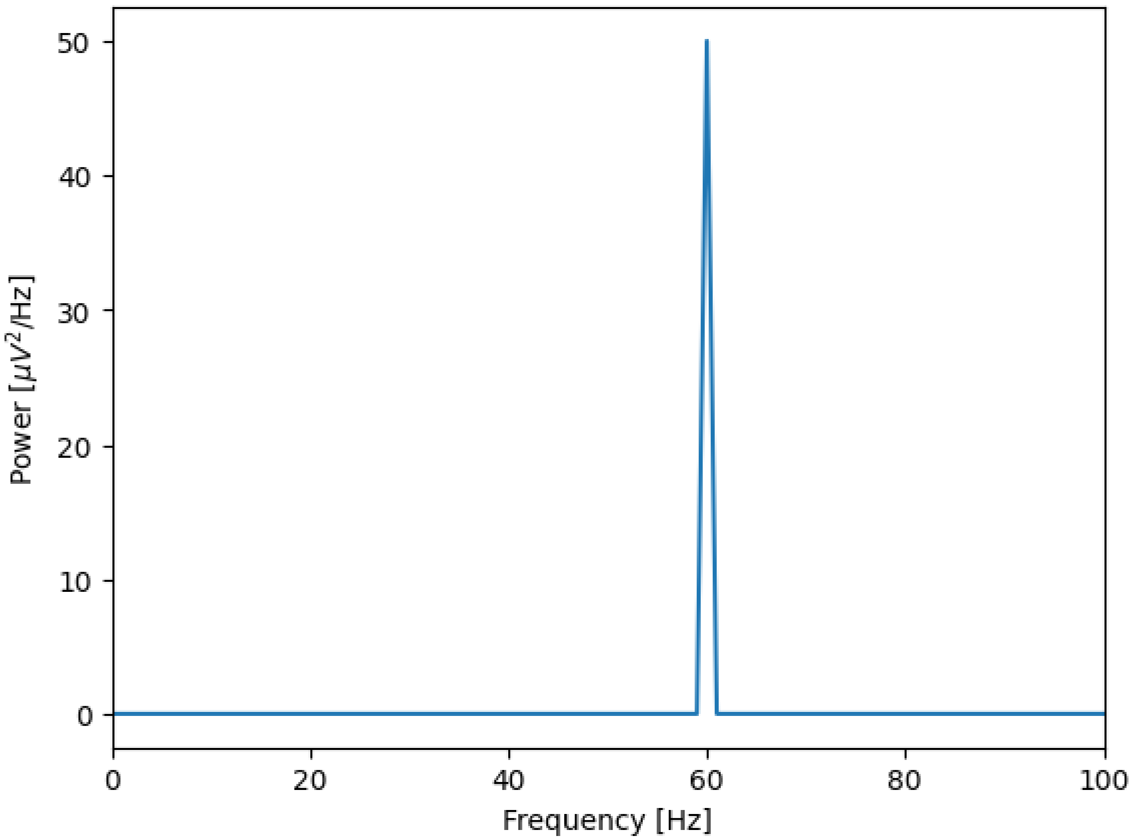
In [ ]:
```
#frequency axis
fj  = np.arange(0,fNQ,df)

x = EEG
X = np.ndarray(np.size(fj), complex);
```

```
for j in range( np.size(fj) ):
    X[j] = np.sum(x * np.exp(-2 * np.pi * 1j * fj[j] * t)) #1j is the square root o

# And the spectrum,
Sxx = 2*dt**2/T * X * np.conj(X) #Sxx at frequency index j

# Plot
plt.plot(fj, Sxx.real)
plt.xlim([0, 100])                          # Select frequency range
plt.xlabel('Frequency [Hz]')
plt.ylabel('Power [$\mu V^2$/Hz]');
plt.show()
```



1 vi. Plot the spectrum versus frequency. You may choose to plot the spectrum on a decibel scale, or not. Defend your choice!

In [ ]:

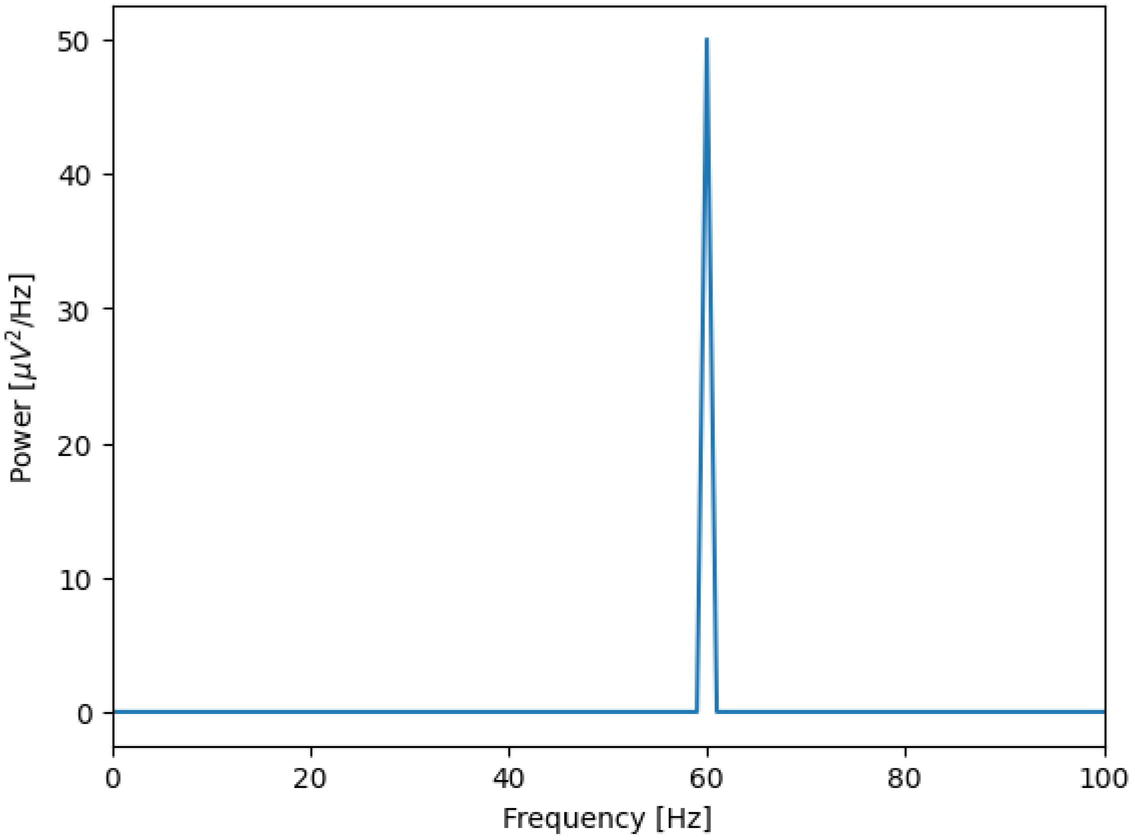
```
# Compute the power spectrum using the FFT function.
#Define useful quantities
dt = t[2]-t[1]
f0 = 1/dt
N = np.size(EEG)
T = N*dt

x  = EEG
xf = np.fft.fft(x)                         # Compute Fourier transform of x
Sxx = 2 * dt ** 2 / T * (xf * xf.conj())   # Compute spectrum
Sxx = Sxx[0:int(N / 2)].real               # Ignore negative frequencies

# Define the frequency axis
```

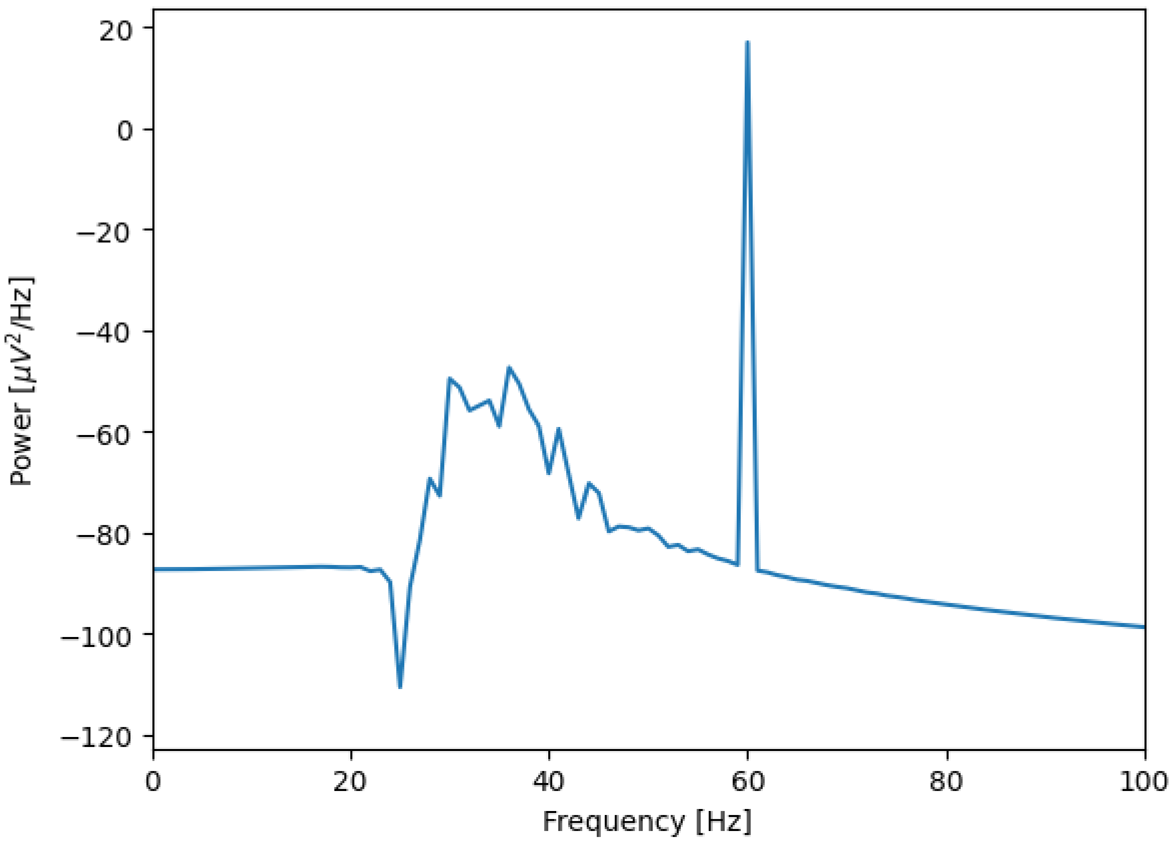
```
df = 1/T                          # Determine frequency resolution
fNQ = f0 / 2                      # Determine Nyquist frequency
faxis = np.arange(0,fNQ,df)  # Construct frequency axis

# Plot the spectrum versus frequency.
plt.plot(faxis, Sxx)                          #plt.plot(faxis, 10*np.log10(Sxx))  for
plt.xlim([0, 100])                            # Select frequency range
plt.xlabel('Frequency [Hz]')                  # Label the axes
plt.ylabel('Power [$\mu V^2$/Hz]');
```



In [ ]:

```
plt.plot(faxis, 10*np.log10(Sxx))  #for decibels
plt.xlim([0, 100])                            # Select frequency range
plt.xlabel('Frequency [Hz]')                  # Label the axes
plt.ylabel('Power [$\mu V^2$/Hz]');
```

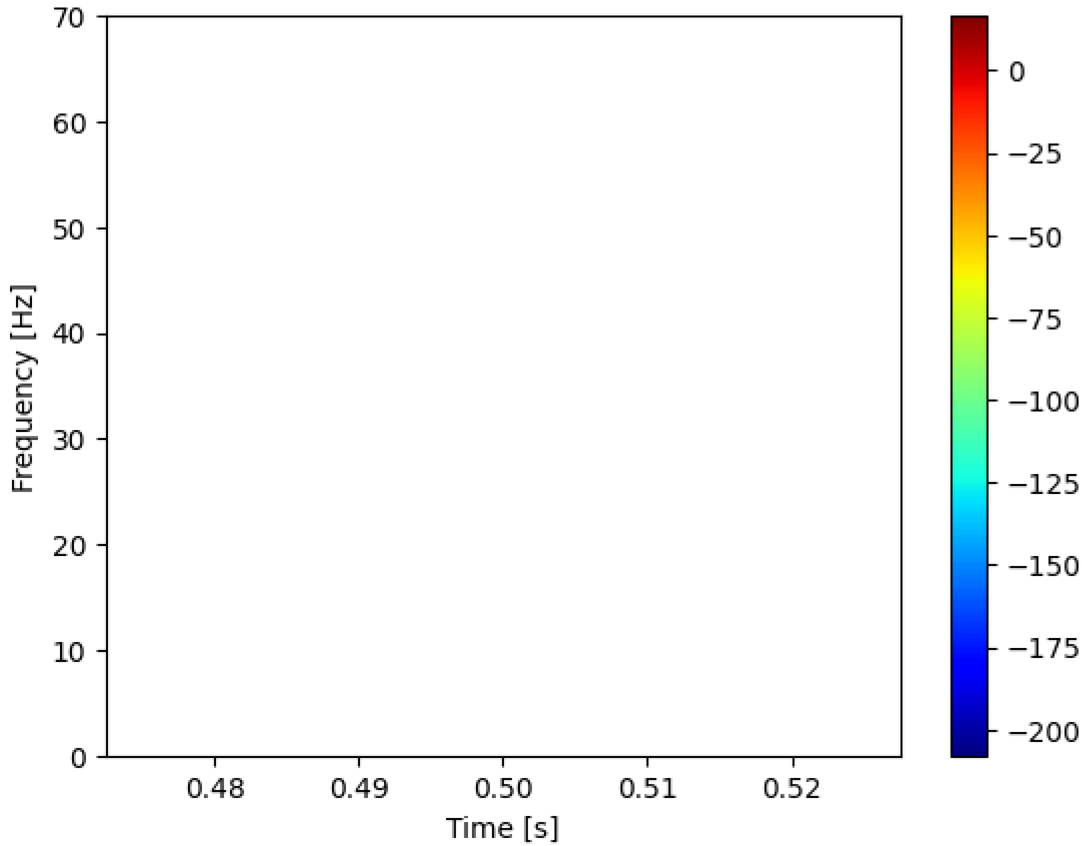


I chose to plot using a decibel scale because the decibal scale emphasizes lower-amplitutde rhythmns that may be hiden by large-amplitude oscillations. By changing the scale of the spectrum to decibel, we did not uncover any rhythmn like activity, but we are able to confirm that more clearly using this scaling method.

1 vii. Plot the spectrogram as a function of frequency and time. You will need to choose the interval size and the overlap between intervals. Do the rhythms in these data appear to change in time?

In [ ]:
```
# Plot the spectrogram.
Fs = 1 / dt                   # Define the sampling frequency,
interval = int(Fs)            # ... the interval size,
overlap = int(Fs * 0.55)      # ... and the overlap intervals

                              # Compute the spectrogram
f0, t0, Sxx0 = spectrogram(
    EEG,                      # Provide the signal,
    fs=Fs,                    # ... the sampling frequency,
    nperseg=interval,         # ... the length of a segment,
    noverlap=overlap)         # ... the number of samples to overlap,
plt.pcolormesh(t0, f0, 10 * np.log10(Sxx0),
               cmap='jet')# Plot the result
plt.colorbar()                # ... with a color bar,
plt.ylim([0, 70])                 # ... set the frequency range,
plt.xlabel('Time [s]')          # ... and label the axes
plt.ylabel('Frequency [Hz]');
```

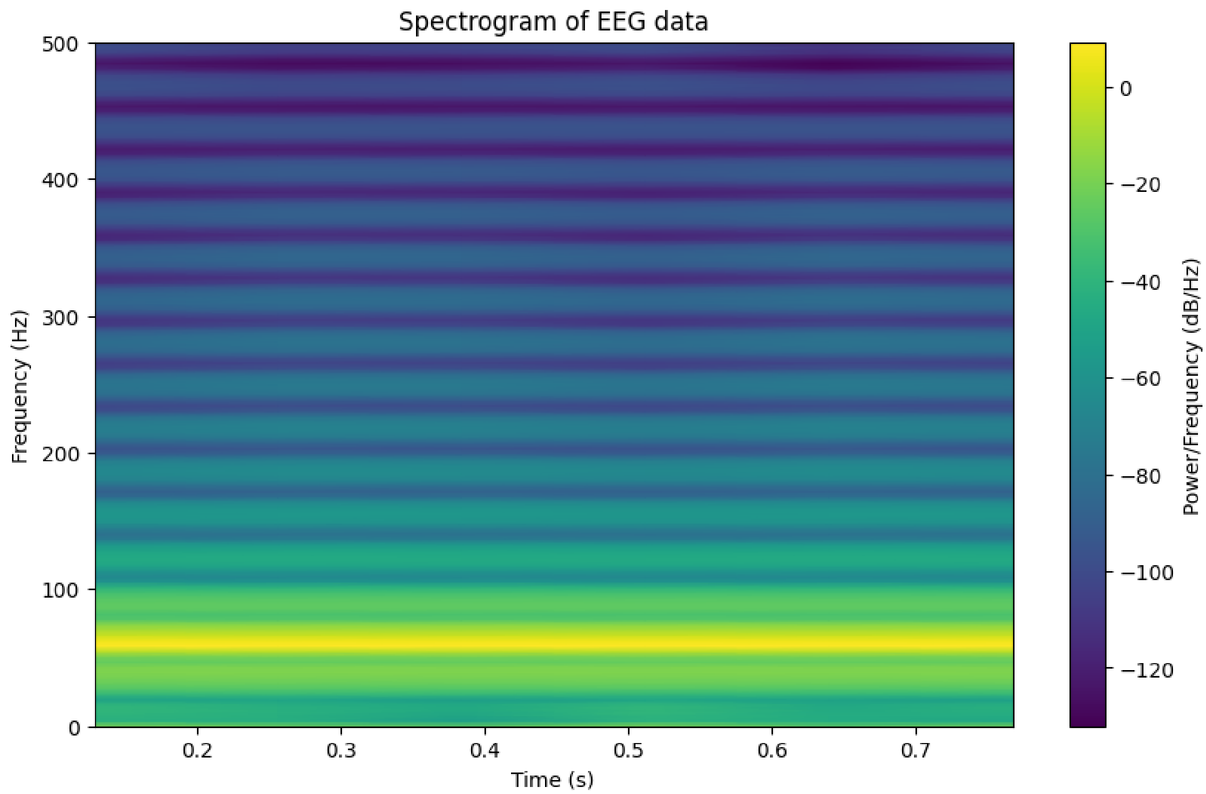


In [ ]:

```
window_size = 256
overlap = 128

#compute spectrogram
f, t, Sxx = spectrogram(EEG, fs=1/dt, nperseg=window_size, noverlap = overlap, nfft

#plot spectrogram
plt.figure(figsize = (10, 6))
plt.pcolormesh(t, f, 10 * np.log10(Sxx), shading='gouraud') #plot in decibels with
plt.colorbar(label = 'Power/Frequency (dB/Hz)')
plt.xlabel('Time (s)')
plt.ylabel('Frequency (Hz)')
plt.title('Spectrogram of EEG data')
plt.show()
```



Do the rhythms in these data appear to change in time?

It doesn't appear to be changing much over time, if anything, the frequencies seem pretty stable across time.

1 viii.) Interpret (in a few sentences) the spectrum and spectrogram, and describe the rhythms present in the signal. Compare your visual inspection of the data to the spectrum results - do the analyses agree or disagree?

There doesn't appear to be any rhythms present within the spectrogram. The activity throughout the timeframe looks relatively stable. This is a bit suprising since the graph of the spectrum seems to imply stark changes in activity level. The spectrogram analysis, however, shows otherwise.

1. Load the file: EEG-2.mat, available on the Github repository into Python. i. What is the sampling interval? ii. What is the total duration of the recording (T)?

   iii. What is the frequency resolution (df)?

   iv. What is the Nyquist frequency (fNQ)?

   v. Plot the data and visually inspect it. Describe briefly (in a sentence or two) what rhythms - if any - you see in the data.

   vi. Plot the spectrum versus frequency. You may choose to plot the spectrum on a decibel scale, or not. Defend your choice!

vii. Plot the spectrogram as a function of frequency and time. You will need to choose the interval size and the overlap between intervals. Do the rhythms in these data appear to change in time?

viii. Interpret (in a few sentences) the spectrum and spectrogram, and describe the rhythms present in the signal. Compare your visual inspection of the data to the spectrum results - do the analyses agree or disagree?

2. Repeat Question (1) for the data set EEG-3.mat. Be sure to address each sub-question.

3. Repeat Question (1) for the data set EEG-4.mat. Be sure to address each sub-question.

4. Repeat Question (1) for the data set EEG-5.mat. Be sure to address each sub-question.

5. Consider the function $x(t) = sin(2pit^2)$. That's a "t squared" input in the sin function.

   i. Simulate this function in Python using a sampling interval of dt = 0.001 s, and t = (0, 10) s.

   ii.Compute the spectrum, and compute the spectrogram.

   iii.Explain the results you find in each case, and how these results compare to your expectations.