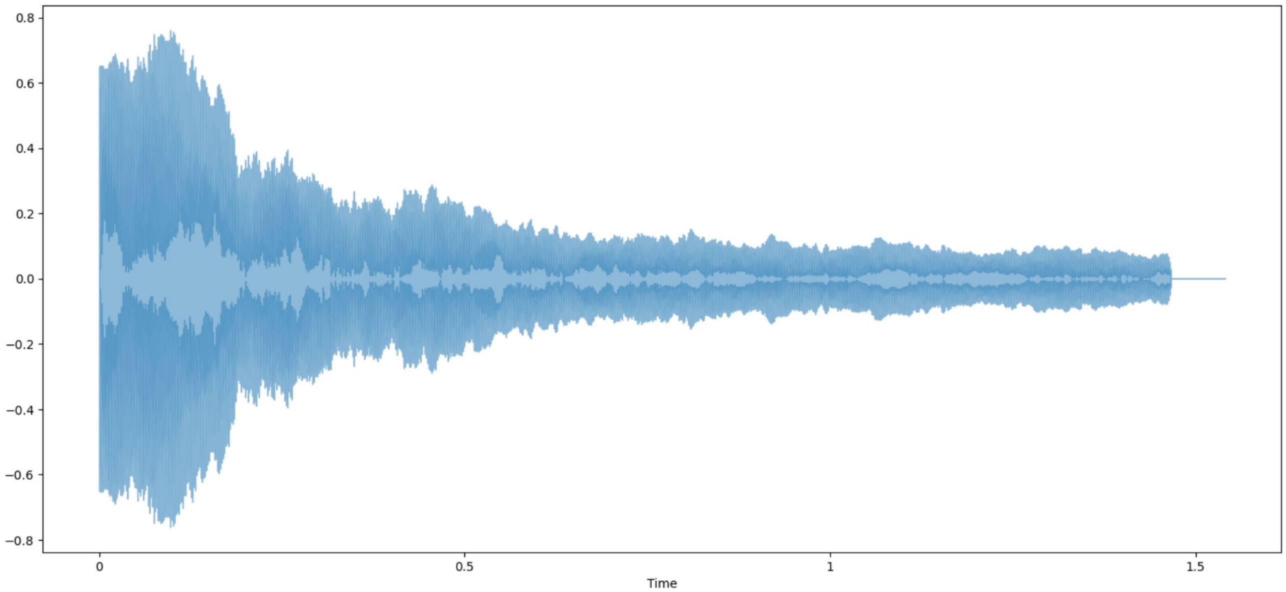
In [5]:
```
import librosa
import librosa.display
import scipy as sp
import IPython.display as ipd
import matplotlib.pyplot as plt
import numpy as np
```

In [6]:
```
# load audio file in the player
audio_path = "audio/piano_c.wav"
ipd.Audio(audio_path)
```

Out[6]:

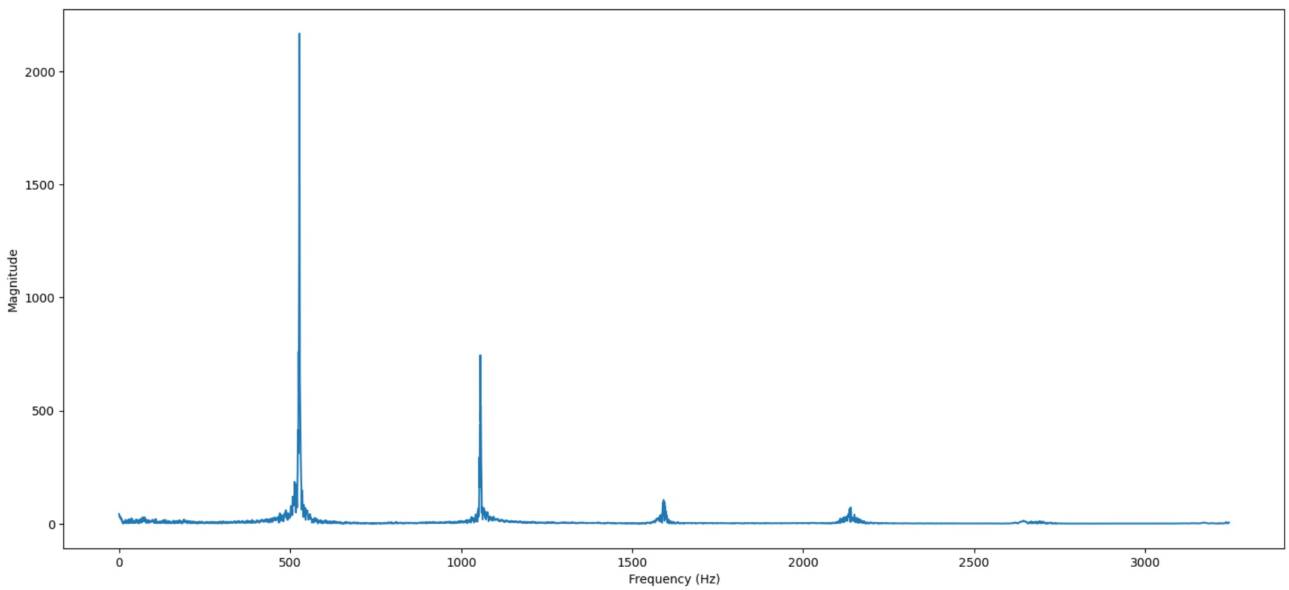
In [7]:
```
# load audio file
signal, sr = librosa.load(audio_path)
```

In [8]:
```
# plot waveform
plt.figure(figsize=(18, 8))
librosa.display.waveshow(signal, sr=sr, alpha=0.5)
plt.show()
```



In [9]:
```
# derive spectrum using FT
ft = sp.fft.fft(signal)
magnitude = np.absolute(ft)
frequency = np.linspace(0, sr, len(magnitude))
```

In [10]:
```
# plot spectrum
plt.figure(figsize=(18, 8))
plt.plot(frequency[:5000], magnitude[:5000]) # magnitude spectrum
plt.xlabel("Frequency (Hz)")
plt.ylabel("Magnitude")
plt.show()
```



In [11]:
```
len(signal)
```

Out[11]:
```
33968
```

In [12]:
```
d =  1 / sr
d
```

Out[12]:
```
4.5351473922902495e-05
```

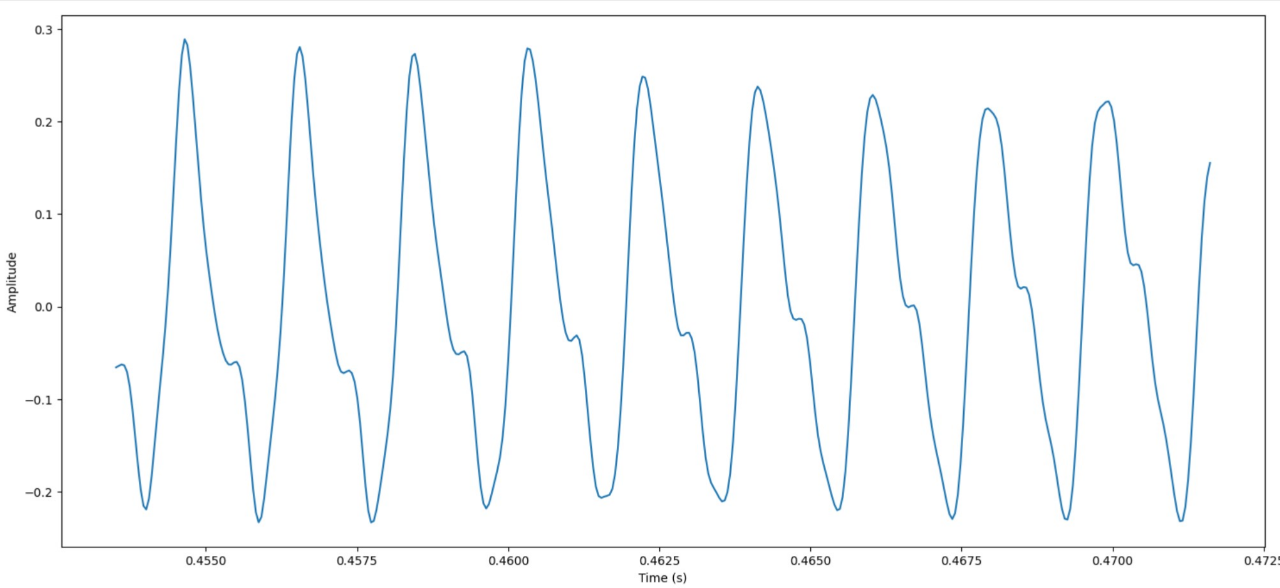
In [13]:
```
d_523 = 1 / 523
d_523
```

Out[13]:
```
0.0019120458891013384
```

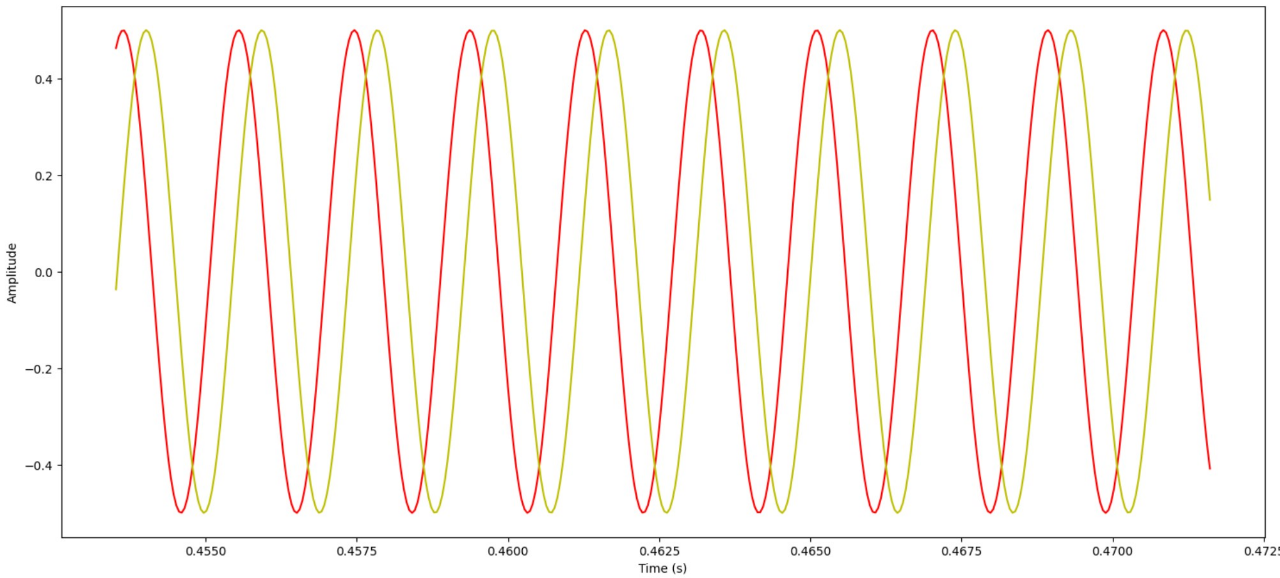
In [14]:
```
d_400_samples = 400 * d
d_400_samples
```

Out[14]:
```
0.018140589569160998
```

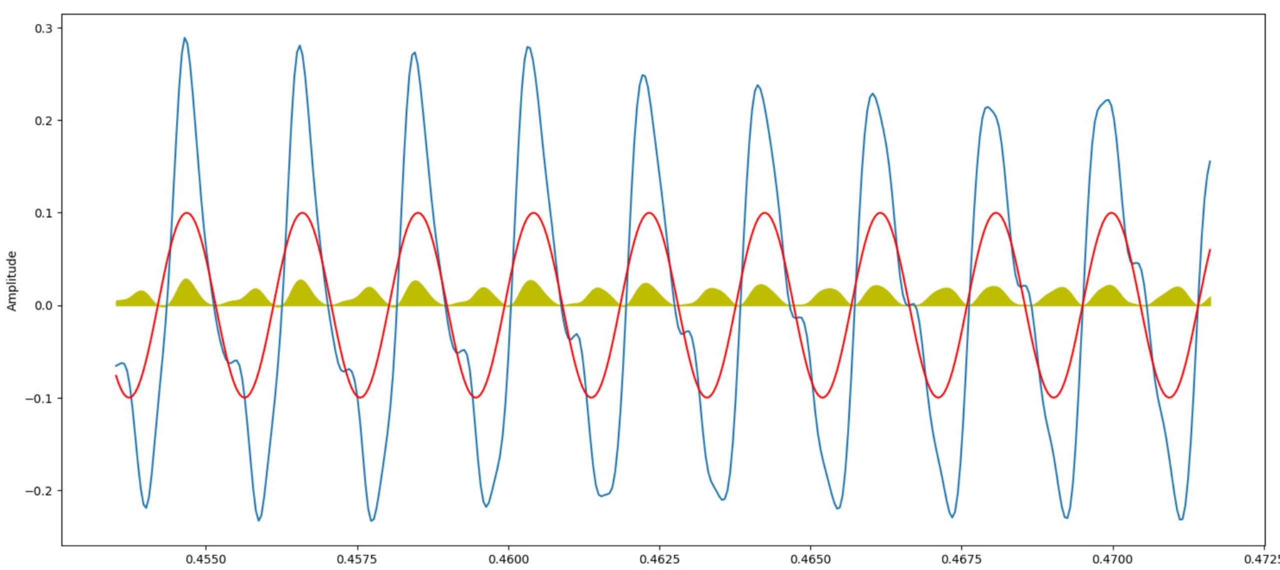
In [15]:
```
# zomm in to the waveform
samples = range(len(signal))
t = librosa.samples_to_time(samples, sr=sr)

plt.figure(figsize=(18, 8))
plt.plot(t[10000:10400], signal[10000:10400])
plt.xlabel("Time (s)")
plt.ylabel("Amplitude")
plt.show()
```



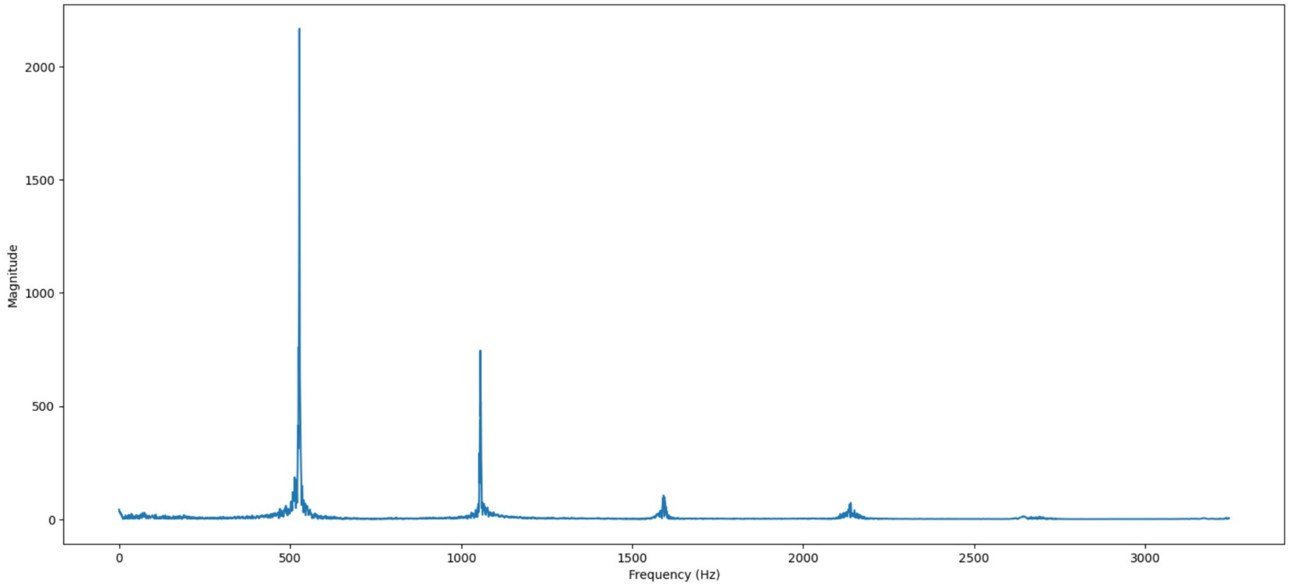
In [16]:
```python
# create a sinusoid

f = 523
phase = 0
phase2 = 0.2

sin = 0.5 * np.sin(2*np.pi * (f * t - phase))
sin2 = 0.5 * np.sin(2*np.pi * (f * t - phase2))

plt.figure(figsize=(18, 8))
plt.plot(t[10000:10400], sin[10000:10400], color="r")
plt.plot(t[10000:10400], sin2[10000:10400], color="y")


plt.xlabel("Time (s)")
plt.ylabel("Amplitude")
plt.show()
```



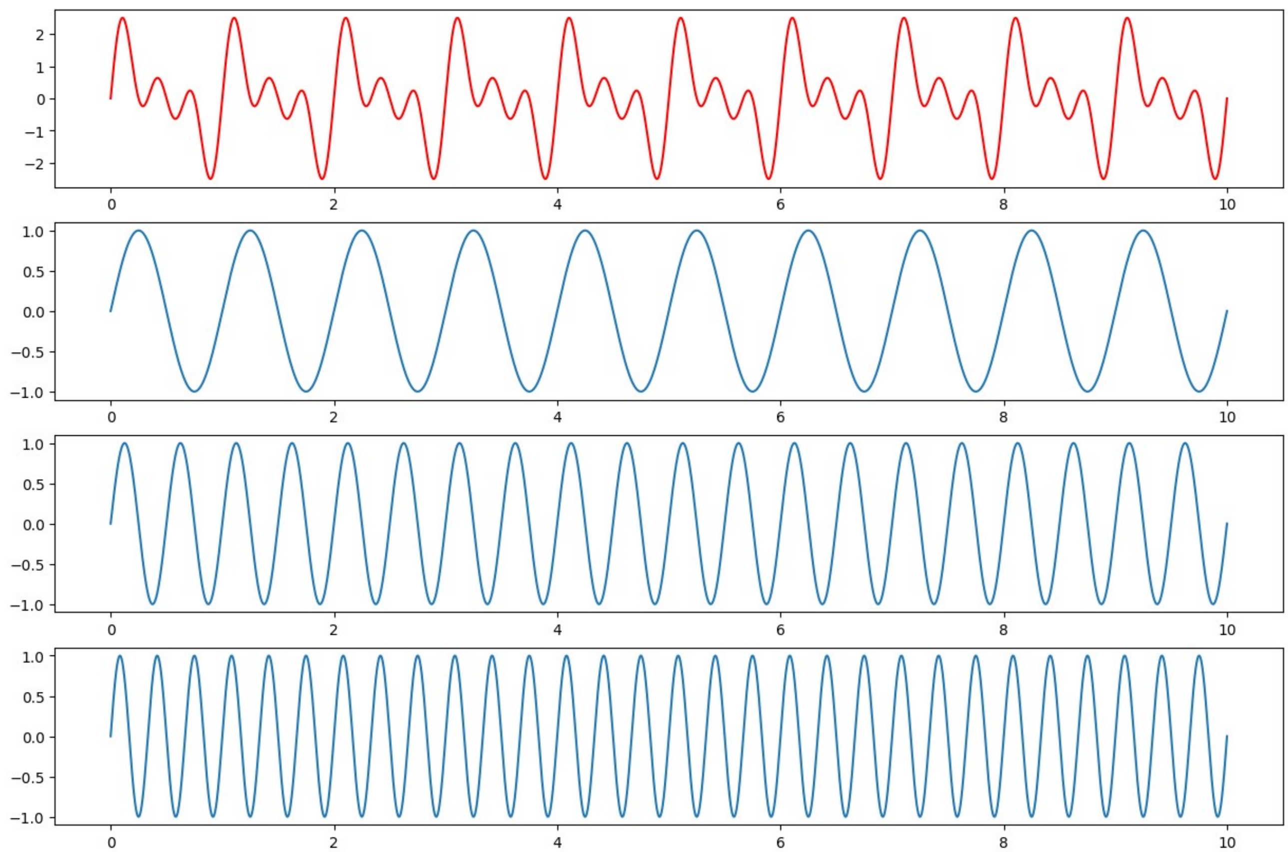
In [17]:
```python
# compare signal and sinusoids

f = 523
phase = 0.55

sin = 0.1 * np.sin(2*np.pi * (f * t - phase))

plt.figure(figsize=(18, 8))
plt.plot(t[10000:10400], signal[10000:10400])
plt.plot(t[10000:10400], sin[10000:10400], color="r")

plt.fill_between(t[10000:10400], sin[10000:10400]*signal[10000:10400], color="y")

plt.xlabel("Time (s)")
plt.ylabel("Amplitude")
plt.show()
```



In [18]:
```
# plot spectrum
plt.figure(figsize=(18, 8))
plt.plot(frequency[:5000], magnitude[:5000]) # magnitude spectrum
plt.xlabel("Frequency (Hz)")
plt.ylabel("Magnitude")
plt.show()
```



In [19]:
```
# superimposing pure tones
f = 1
t = np.linspace(0, 10, 10000)

sin = np.sin(2*np.pi * (f * t))
sin2 = np.sin(2*np.pi * (2*f * t))
sin3 = np.sin(2*np.pi * (3*f * t))

sum_signal = sin + sin2 + sin3

plt.figure(figsize=(15, 10))

plt.subplot(4, 1, 1)
plt.plot(t, sum_signal, color="r")

plt.subplot(4, 1, 2)
plt.plot(t, sin)

plt.subplot(4, 1, 3)
plt.plot(t, sin2)

plt.subplot(4, 1, 4)
plt.plot(t, sin3)

plt.show()
```



2
1
0
−1
−2
1.0
0.5
0.0
−0.5
−1.0
0
2
4
6
8
10