Spectrogram

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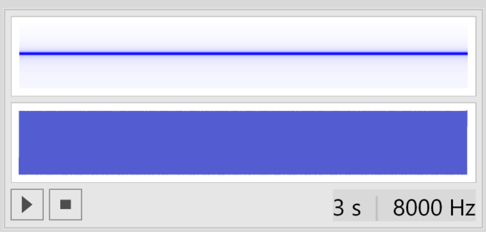
Spectogram of a pure sinusoidal wave

This is the sound of a pure sinusoidal wave (if you are reading this document in *Mathematica* or the *CDFPlayer*, press the button ▶ in the result of the calculation below):

In[1]:=

```
freq = 440;
Play[Sin[2 * π * freq * t], {t, 0, 3}]
```

Out[2]=

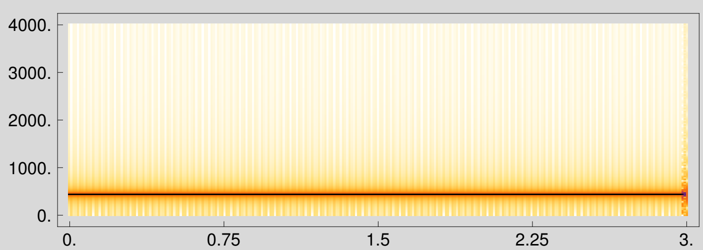


The Spectrogram shows time in the horizontal axis and frequency in the vertical one, in this case a single, constant frequency becomes a single, horizontal line:

In[3]:=

```
freq = 440;
Spectrogram[Play[Sin[2 * π * freq * t], {t, 0, 3}]]
```

Out[4]=



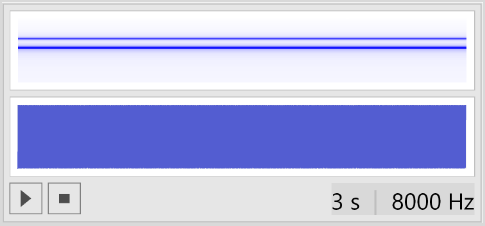
Spectogram of sums of sinusoidal waves

This is the sound of the sum of two sinusoidal waves:

In[5]:=

```
freq = 440;
freq2 = 880;
Play[Sin[2 * π * freq * t] + 1/2 * Sin[2 * π * freq2 * t], {t, 0, 3}]
```

Out[7]=

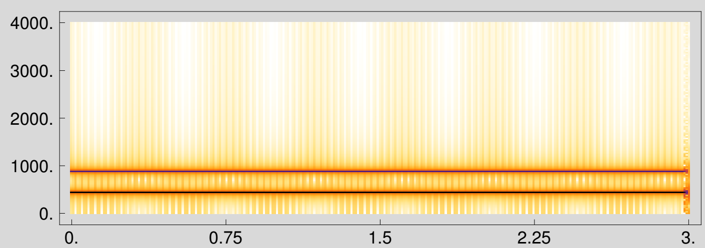


And below we have the corresponding spectrogram, with two lines that correspond to the two frequencies:

In[8]:=

```
freq = 440;
freq2 = 880;
Spectrogram[Play[Sin[2 * π * freq * t] + 1/2 * Sin[2 * π * freq2 * t], {t, 0, 3}]]
```

Out[10]=



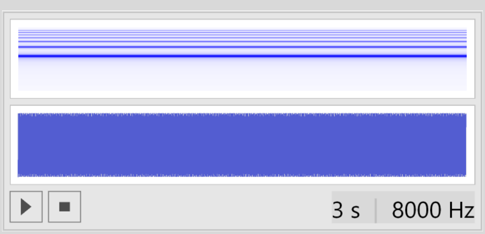
This is the sound of the sum of several sinusoidal waves:

In[11]:=

```
Play[Sum[(1/k * Sin[2 * k * Pi * 440 * t]), {k, 1, 7}], {t, 0, 3}]
```

$$\text{Play}\left[\sum_{k=1}^{7}\left(\frac{1}{k} * \text{Sin}[2 * k * \text{Pi} * 440 * t]\right), \{t, 0, 3\}\right]$$

Out[11]=

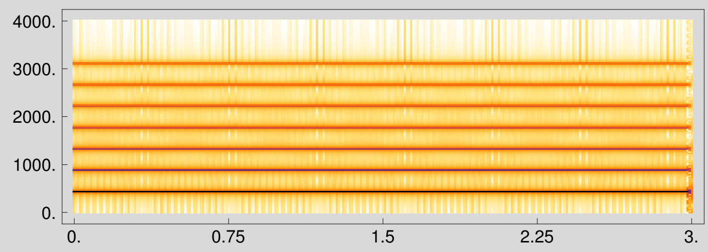


And below we have the corresponding spectrogram, with several lines that correspond to the several frequencies. Darker means a larger constant multiplying the corresponding sinusoidal wave:

In[12]:=

$$\text{Spectrogram}\left[\text{Play}\left[\sum_{k=1}^{7}\left(\frac{1}{k} * \text{Sin}[2 * k * \text{Pi} * 440 * t]\right), \{t, 0, 3\}\right]\right]$$

Out[12]=



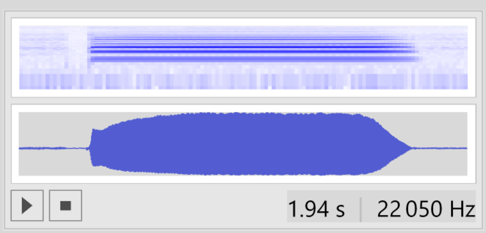
Spectrogram of an Oboe Recording

Below an Oboe recording (a WAV file) included in every computer that has *Mathematica* is loaded and stored in the variable “recording”:

In[14]:=

```
recording = ExampleData[{"Sound", "Oboe"}]
```

Out[14]=

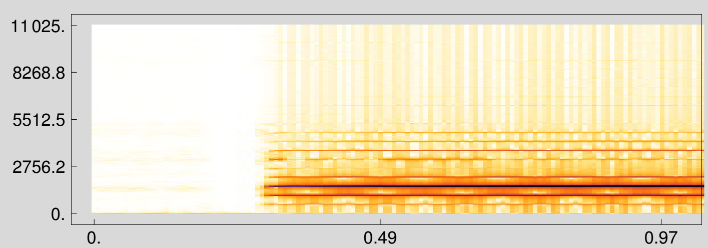


And below we have the corresponding spectrogram, with several lines that correspond to the several frequencies (harmonics, overtones) present:

In[15]:=

```
recording = ExampleData[{"Sound", "Oboe"}];
Spectrogram[recording]
```

Out[16]=



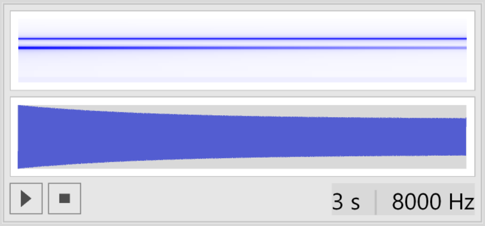
Fading Frequencies

Below you have a sound where one of the frequencies is fanding, because it is multiplied times an exponential with a negative argument, as you can see below:

In[25]:=

```
freq = 440;
freq2 = 880;
Play[Exp[-t] * Sin[2 * π * freq * t] + Sin[2 * π * freq2 * t], {t, 0, 3}]
```

Out[27]=

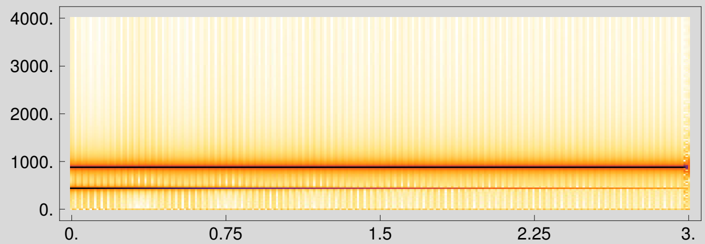


The spectrogram shows that for large times, one of the frequencies has a smaller amplitude:

In[28]:=

```
Spectrogram[Play[Exp[-t] * Sin[2 * π * freq * t] + Sin[2 * π * freq2 * t], {t, 0, 3}]]
```

Out[28]=



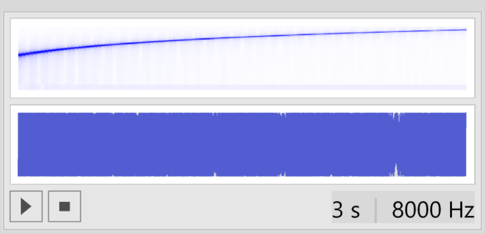
A Chirp with a Variable Frequency

A sinusoidal wave with a a variable frequency is shown below:

In[38]:=

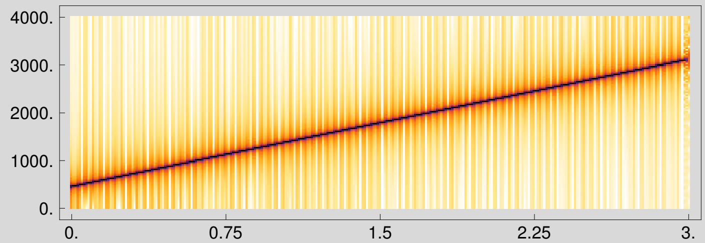
```
freq = 440 * (t + 1);
Play[Sin[2 * π * freq * t], {t, 0, 3}]
```

Out[39]=



The corresponding spectrogram is shown below. It clearly shows the increasing frequency of the sinusoidal wave:

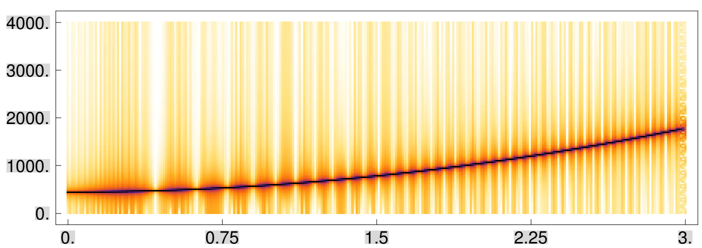
In[40]:=
```
freq = 440 * (t + 1);
Spectrogram[Play[Sin[2 * π * freq * t], {t, 0, 3}]]
```

Out[41]=


Exercises

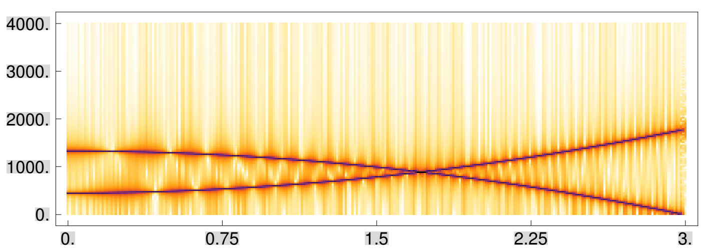
Exercise 1

Use *Mathematica* to generate a sound that has this spectrogram:



Exercise 2

Use *Mathematica* to generate a sound that has this spectrogram:



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In[56]:=

```
{DateString[], $Version}
```

Out[56]=

```
{Tue 10 Mar 2015 12:44:48,
 10.0 for Microsoft Windows (64-bit) (December 4, 2014)}
```