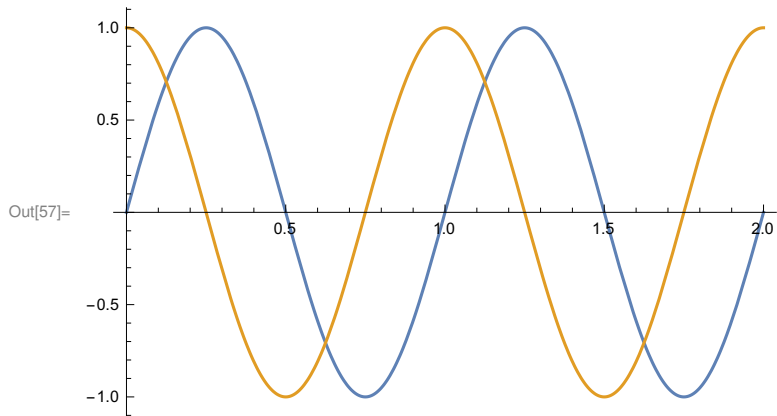

Phase of Waves

```
In[55]:= f = 1; (* Frequency *)  
         ϕ = 90; (* Phase *)
```

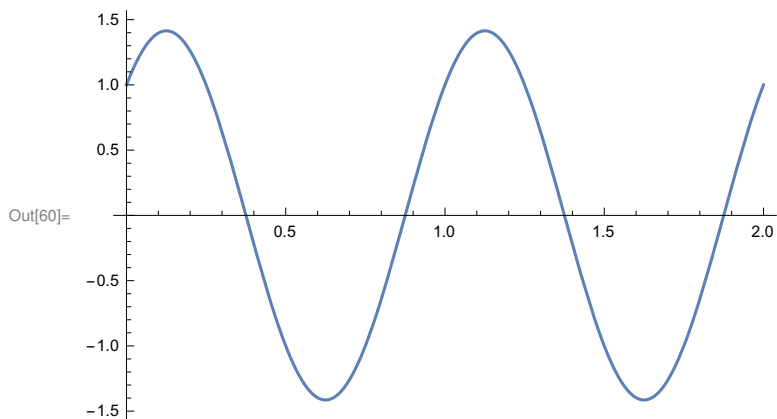
```
Plot[ { Sin[2 π f t], Sin[2 π f t + 2 π  $\frac{\phi}{360}$ ] }, {t, 0, 2}]
```



Adding Waves

```
In[58]:= f = 1; (* Frequency *)  
         ϕ = 90; (* Phase *)
```

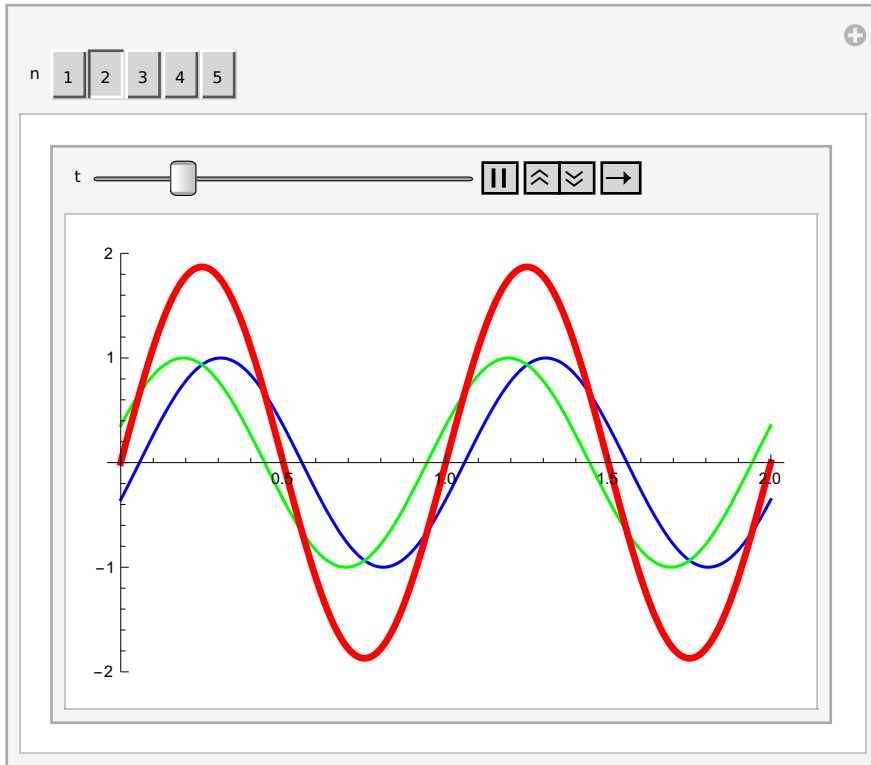
```
Plot[ { Sin[2 π f t] + Sin[2 π f t + 2 π  $\frac{\phi}{360}$ ] }, {t, 0, 2}]
```



Animation #1:

```
In[61]:= amp1 = 1.0;  
amp2 = 1.0;  
Manipulate[Animate[Plot[{amp1 Sin[ 2 Pi (x + t)], amp2 Sin[ 2 Pi (x - t)],  
amp1 Sin[ 2 Pi (x + t)] + amp2 Sin[ 2 Pi (x - t)]}, {x, 0, n}, PlotRange → {-2, 2},  
PlotStyle → {Blue, Green, {Red, Thickness[0.010]}}, {t, 0, 2}]  
, Control[{{n, 2}, {1, 2, 3, 4, 5}}]]
```

Out[63]=



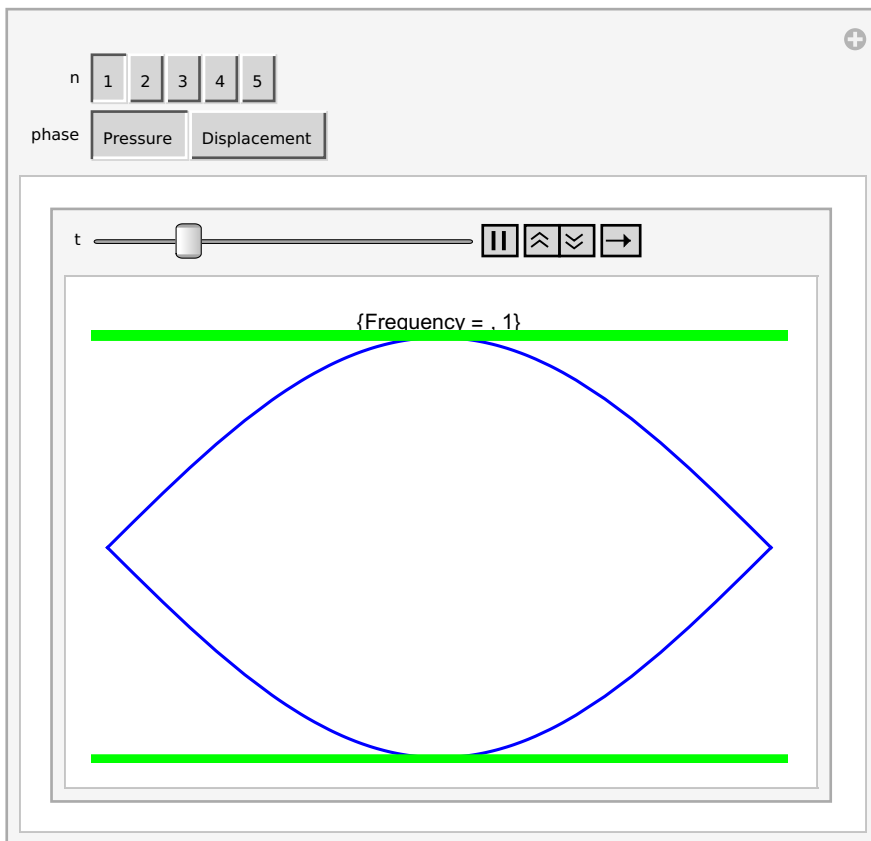
Animation #2:

```

In[64]:= open = {Thickness[0.02], Green, Line[{{-10, -2}, {10, -2}}, Line[{{-10, +2}, {10, +2}}]} ;
Manipulate[
  Animate[
    Plot[{Sin[2 Pi (x + n t) +  $\pi$  phase] + Sin[2 Pi (x - n t) +  $\pi$  phase],
      -Sin[2 Pi (x + n t) +  $\pi$  phase] - Sin[2 Pi (x - n t) +  $\pi$  phase ]}, {x, 0, n/2},
    PlotRange  $\rightarrow$  {-2, 2},
    PlotStyle  $\rightarrow$  {Blue, Blue},
    PlotLabel  $\rightarrow$  {"Frequency = ", n},
    Axes  $\rightarrow$  False,
    Epilog  $\rightarrow$  open
  ]
  , {t, 0, 1}
  , Control[{n, {1, 2, 3, 4, 5}},
  Control[{{phase, 0}, {0  $\rightarrow$  "Pressure", 1/2  $\rightarrow$  "Displacement"}}]]

```

Out[65]=



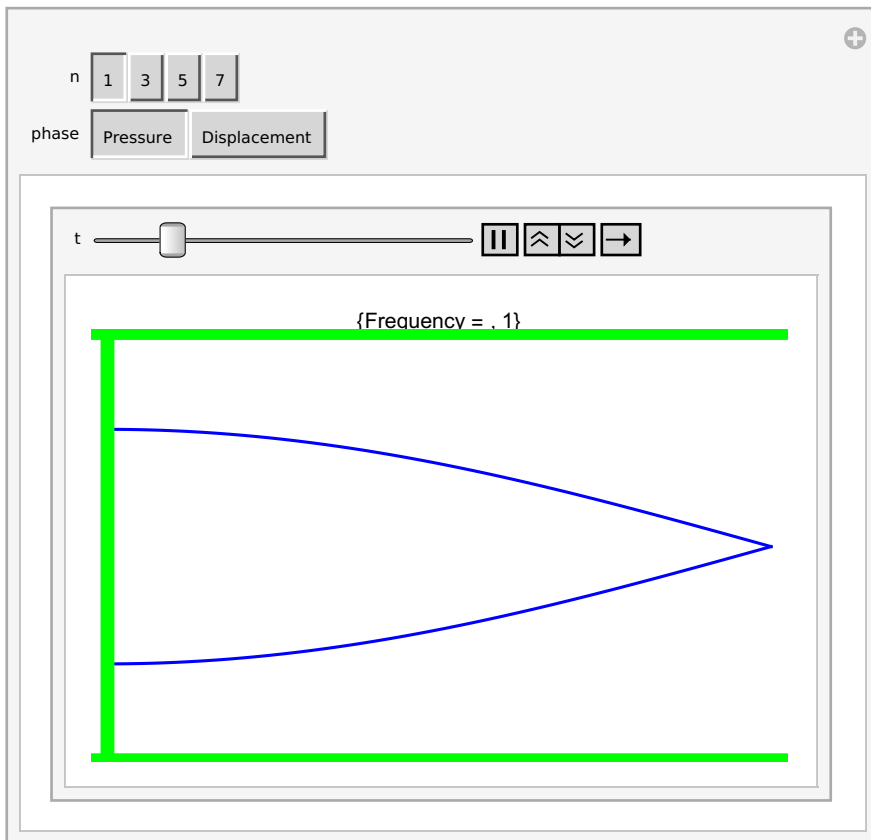
Animation #3:

```

In[66]:= closed = {Thickness[0.02], Green, Line[{{-10, -2}, {10, -2}}],
  Line[{{-10, +2}, {10, +2}}], Line[{{0, +2}, {0, -2}}]};
Manipulate[
  Animate[
    Plot[{Sin[2 Pi (x + n t) + π phase] + Sin[2 Pi (x - n t) + π phase],
      -Sin[2 Pi (x + n t) + π phase] - Sin[2 Pi (x - n t) + π phase]}, {x, 0, n/4},
    PlotRange → {-2, 2},
    PlotStyle → {Blue, Blue},
    PlotLabel → {"Frequency = ", n},
    Axes → False,
    Epilog → closed
  ]
  , {t, 0, 1}
  , Control[{n, {1, 3, 5, 7}}],
  Control[{{phase, 1/2}, {1/2 → "Pressure", 0 → "Displacement"}}]]

```

Out[67]=



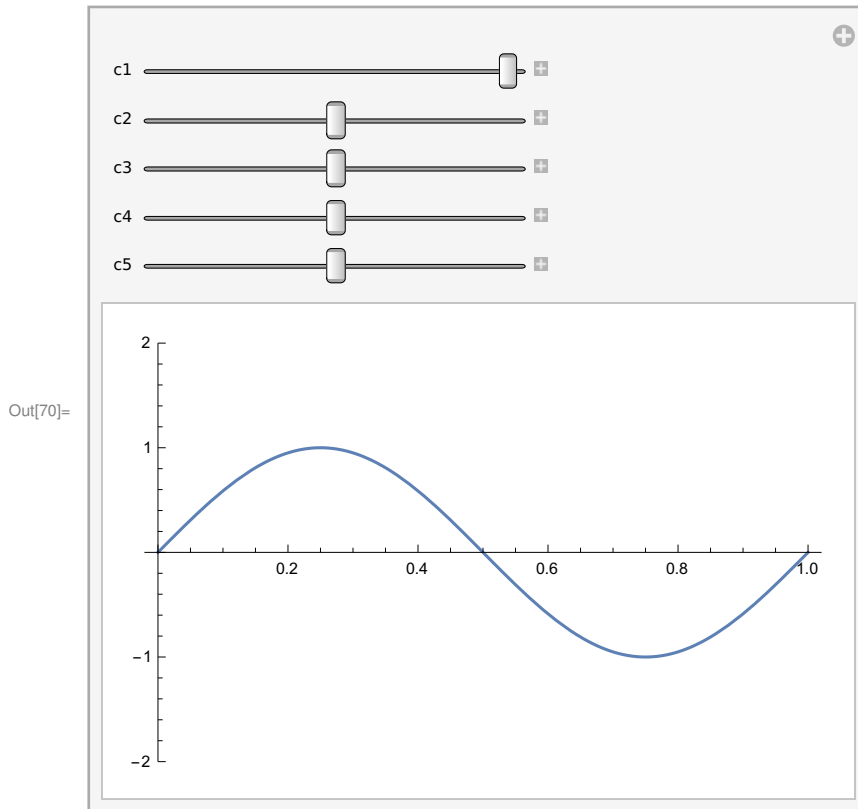
Plot #1: Make a Saw-Tooth Wave

```
In[68]:= fun[x_, c1_, c2_, c3_, c4_, c5_] :=  
         c1 Sin[2 π x] + c2 Sin[2 π 2 x] + c3 Sin[2 π 3 x] + c4 Sin[2 π 4 x] + c5 Sin[2 π 5 x]
```

```
In[69]:= fun[0.1, 1, 2, 3, 4, 5]
```

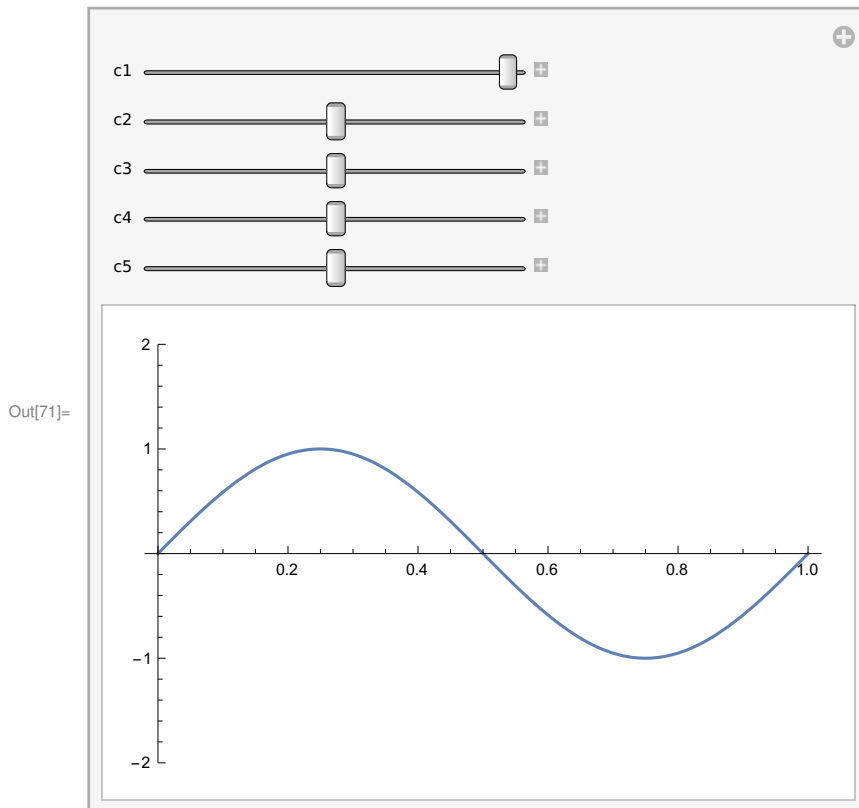
```
Out[69]= 7.69421
```

```
In[70]:= Manipulate[  
  Plot[fun[x, c1, c2, c3, c4, c5], {x, 0, 1}, PlotRange → {-2, 2}],  
  {{c1, 1}, -1, 1, 0.05},  
  {{c2, 0}, -1, 1, 0.05},  
  {{c3, 0}, -1, 1, 0.05},  
  {{c4, 0}, -1, 1, 0.05},  
  {{c5, 0}, -1, 1, 0.05}]
```

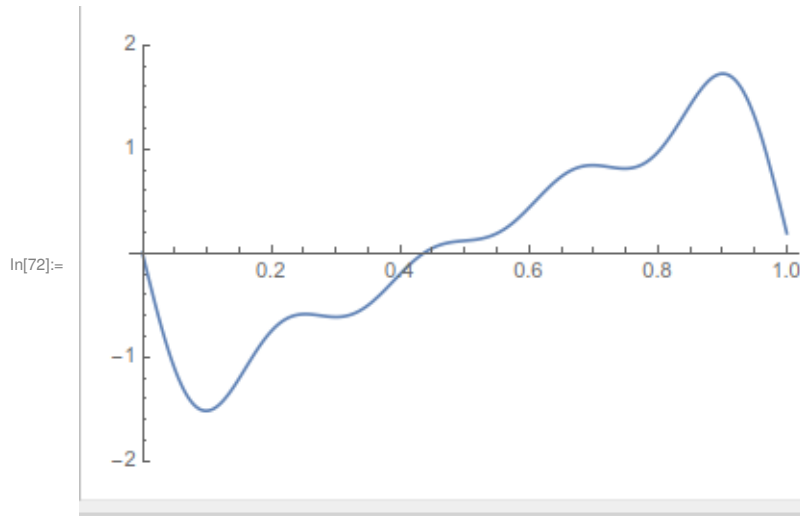


Plot #2: Make a Square Wave

```
In[71]:= Manipulate[  
  Plot[fun[x, c1, c2, c3, c4, c5], {x, 0, 1}, PlotRange → {-2, 2}],  
  {{c1, 1}, -1, 1, 0.05},  
  {{c2, 0}, -1, 1, 0.05},  
  {{c3, 0}, -1, 1, 0.05},  
  {{c4, 0}, -1, 1, 0.05},  
  {{c5, 0}, -1, 1, 0.05}]
```

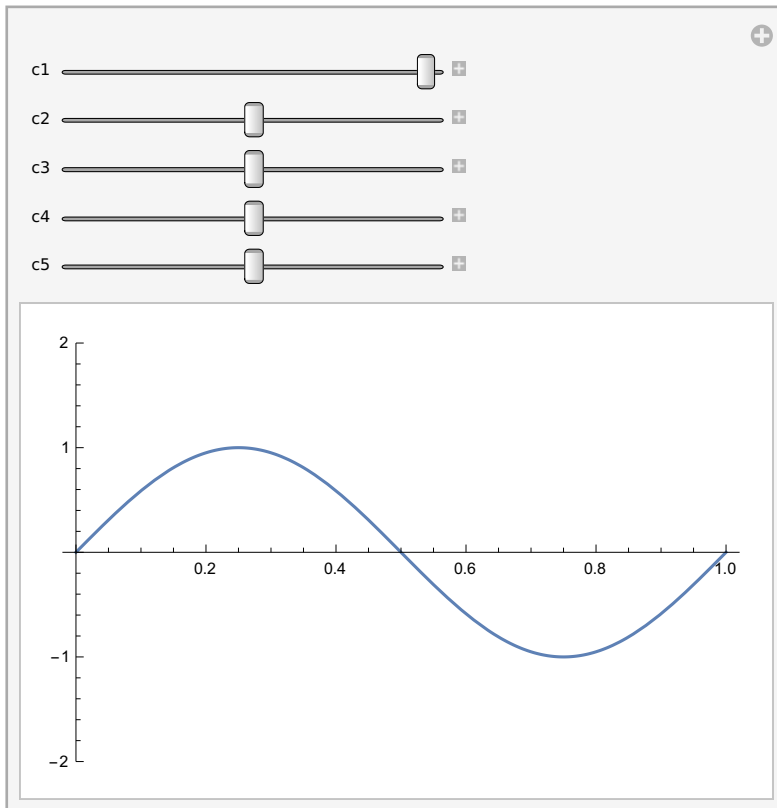


Plot #3: Challenge: Make a different Saw Tooth



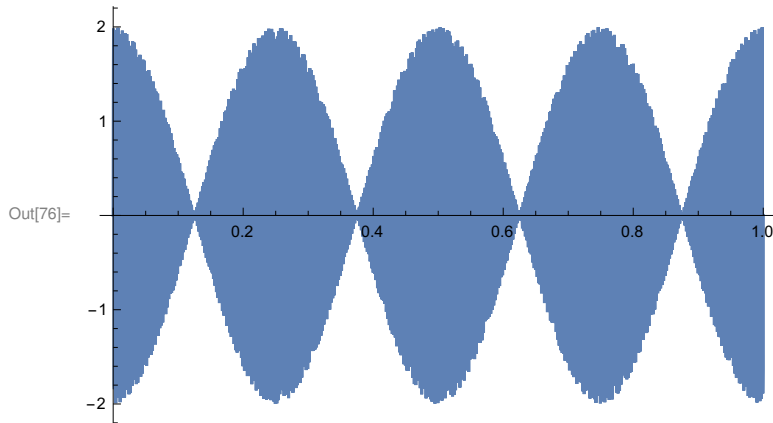
```
In[86]:= Manipulate[  
  Plot[fun[x, c1, c2, c3, c4, c5], {x, 0, 1}, PlotRange → {-2, 2}],  
  {{c1, 1}, -1, 1, 0.05},  
  {{c2, 0}, -1, 1, 0.05},  
  {{c3, 0}, -1, 1, 0.05},  
  {{c4, 0}, -1, 1, 0.05},  
  {{c5, 0}, -1, 1, 0.05}]
```

Out[86]=



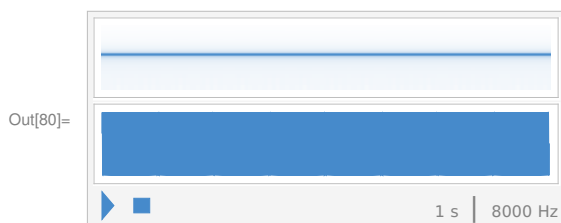
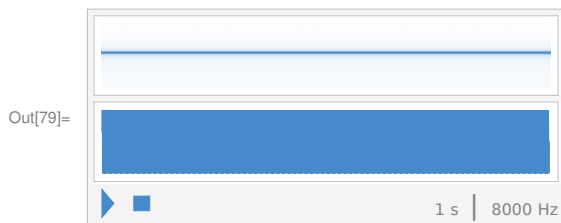
Plot Beats:

```
In[74]:= f1 = 440; (* Frequency *)  
         f2 = 444; (* Frequency *)  
         Plot[{Sin[2  $\pi$  f1 t]+Sin[2  $\pi$  f2 t]}, {t, 0, 1}]
```

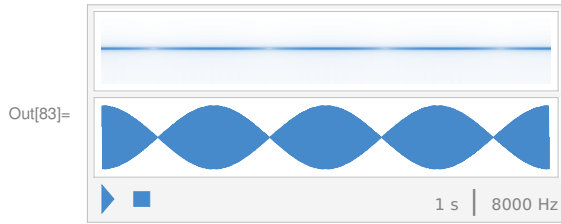


Hear Beats:

```
In[77]:= f1 = 440; (* Frequency *)  
         f2 = 444; (* Frequency *)  
         Play[{Sin[2  $\pi$  f1 t]}, {t, 0, 1}]  
         Play[{Sin[2  $\pi$  f2 t]}, {t, 0, 1}]
```

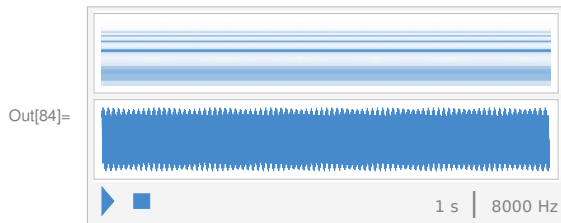


```
In[81]:= f1 = 440; (* Frequency *)
         f2 = 444; (* Frequency *)
         Play[{Sin[2 π f1 t]+Sin[2 π f2 t]}, {t, 0, 1}]
```



Synthetic Instruments #1:

```
In[84]:= Play[fun[440 x , 1, 1/2, 1/3, 1/4, 1/5], {x, 0, 1}]
```



Synthetic Instruments #2:

```
In[85]:= Play[fun[440 x , 1, 0/2, 1/3, 0/4, 1/5], {x, 0, 1}]
```

