Anne Watson

Helmholtz motor:

In this demonstration, four speakers face into a Plexiglas "room" (interior dimensions: 40cm x 40cm x 20cm). At 400 Hz, 40 cm is about half a wavelength ($f = v/\lambda$). This excites standing waves within the box. The Christmas ornaments act as Helmoltz resonators with only one opening. Pressure differences between the neck and the body are established, and the air in the neck begins to vibrate rapidly. That vibrating column in the neck causes a jet of air to flow away from the neck. This is the same principle (involving higher math) used in an ultra-sonic fountain. Each time the opening passes a speaker it gives it a little kick. The jets from the two bulbs create a torque causing the motor to spin. The speakers don't need to be 90° out of phase in order for this to work. In fact, it will work using only one set of speakers (more slowly). The motor has been noted to rotate at frequencies as high as 600 Hz and as low as 200, though the farther off 400 Hz, the slower it will spin.

Initial position is important in this demonstration. The wrong initial position will cause the device to rotate "backwards," as if it were sucking air in. The best position to start in is with one of bulb openings directly facing a speaker. Diagonal starting positions should be avoided.

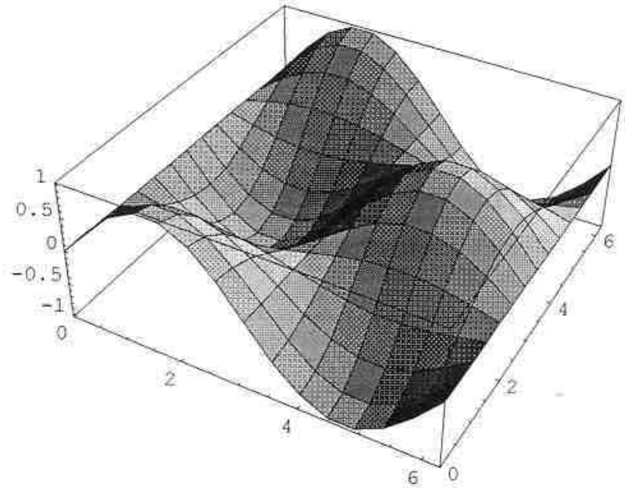
Acoustic Motor (Spinning Cups):

This demo involves four cups located in the centers of the four quadrants of the same 40cm x 40cm x 20 cm Plexiglas box. Each cup is free to rotate on a pivot. At 800 Hz, there's a 90° phase shift from one side of speakers to the other. This creates standing waves allowing one full wavelength to fit inside the box. The pressure differences caused by the standing waves are arranged so that the resulting air movement flows in four circles within the four quadrants. The moving air causes the cups to rotate with it, each corner spinning the opposite direction of its nearest neighbors.

Acoustic Motor (Spinning Cups) :

The 3 D graph below is a picture of the pressure levels of a single wave caught at a particular moment of time at 800 Hz with a 90 ° phase shift.

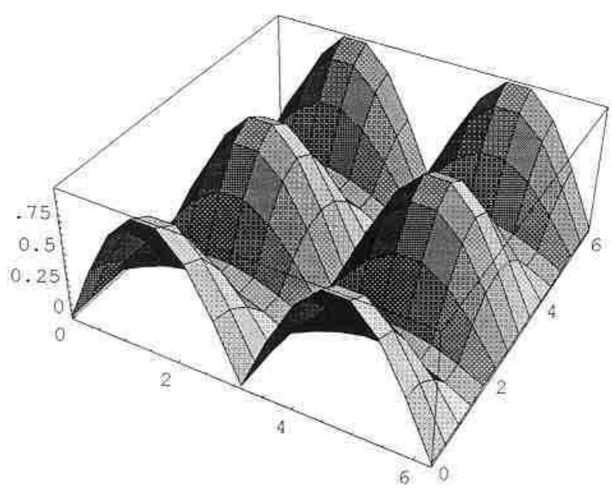
```
Plot3D[Sin[x] Sin[y + .5 π], {x, 0, 2 π}, {y, 0, 2 π}]
```



- SurfaceGraphics -

The 3 D graph below shows the node / antinode formation of the wave at 800 Hz with a 90 ° phase shift. The high points are pressure antinodes and low points are pressure nodes.

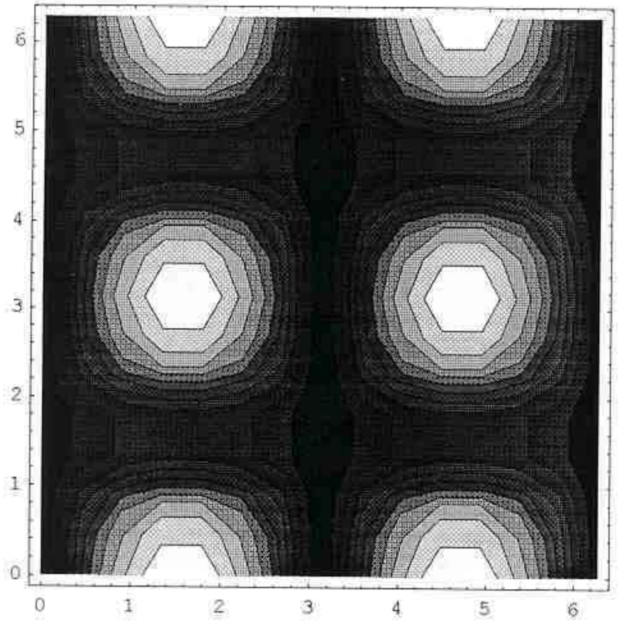
```
Plot3D[Abs[Sin[x] Sin[y + .5 π]], {x, 0, 2 π}, {y, 0, 2 π}]
```



- SurfaceGraphics -

The graph below is a topographical representation of the graph above.

```
ContourPlot[Abs[Sin[x] Sin[y + .5 π]], {x, 0, 2 π}, {y, 0, 2 π}]
```

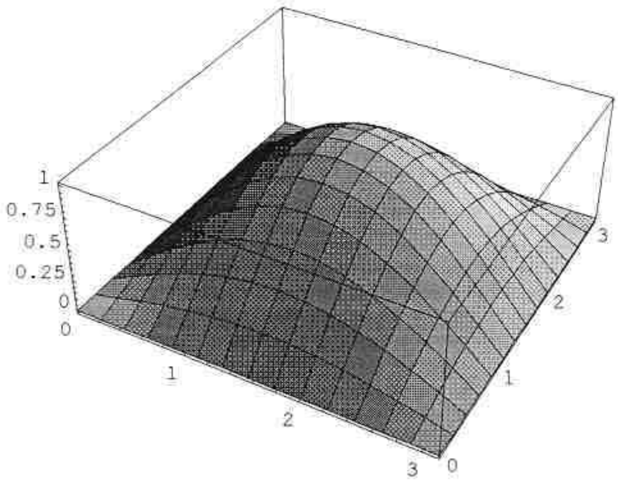


- ContourGraphics -

Helmholtz Motor :

The 3 D graph below shows the air pressure level within the box at 400 Hz with no phase shift. The high point in the middle is the single pressure antinode.

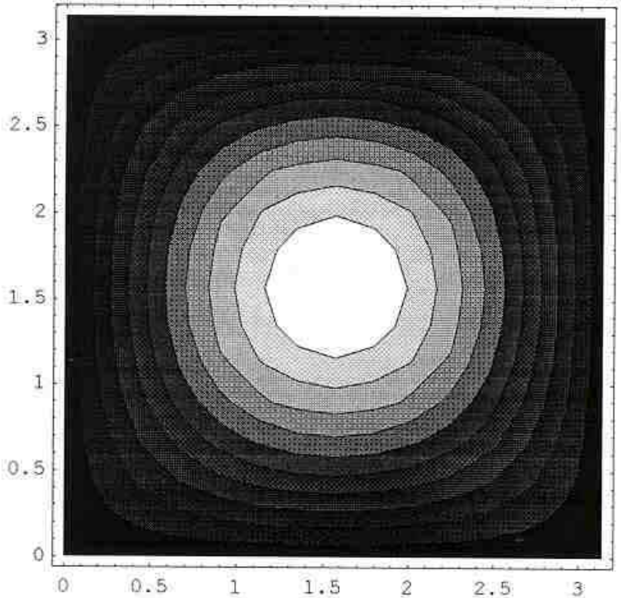
```
Plot3D[Sin[x] Sin[y], {x, 0, π}, {y, 0, π}]
```



- SurfaceGraphics -

The graph below is a topographical representation of the graph above.

```
ContourPlot[Sin[x] Sin[y], {x, 0, π}, {y, 0, π}]
```




```
- ContourGraphics -
```