10.3.2: Vibrating Plate Simulation

This simulation allows you to examine vibrational modes on a rectangular surface. In this case, unlike the Chladni plate in the video, the surface is fixed at the edges so the nodal lines occur in different places compared to a rectangle with free edges. This simulation also models a surface that is very thin and very flexible (a membrane); real surfaces which are stiffer will have slightly different nodal lines and anti-nodes. The effect is very similar, however. Free edged surfaces, thin flexible surfaces and thick stiff surfaces all have nodal lines and anti-node areas.

The buttons at the top allow you to see the first few pure modes. The custom button allows you to look at higher pure modes and to add several modes together. To see a higher order pure mode in the simulation, click the reset button, click the custom button, choose n and m, enter (so the yellow disappears) and click 'add'. If you do *not* click the reset first button the selected mode gets added to the modes that are already present. The simulation can be viewed as a two dimensional surface or as a surface in three dimensions. In the 3D view you can grab the surface with the mouse and rotate it. The amplitudes of the vibrations are exaggerated compared to a real surface to make them more visible. Increasing Δt makes the simulation run faster but also less accurately, particularly for higher mode numbers.

Note

The relative mode amplitudes in the case of more than one mode are not properly normalized in this simulation.

Simulation Questions:

1. Describe the $n=1, \ m=1$ mode in the surface view and in the 3D view. If you sliced through the middle of the surface in the x-direction, which string mode would it look like? How about in the y-direction?
2. What is the frequency of the $n=1, \ m=1$ mode? What is the period?
3. Describe the $n=2, \ m=1$ mode in the surface and 3D view. (Don't forget you can rotate the view using the mouse to get a better angle.) Now if you slice along the x-direction in the middle of the surface which string mode does it look like?
4. For the $n=2$ and $m=1$ mode, how many anti-nodes are along the x-direction? How many anti-nodes are along the y-direction? Describe the location of the nodal line located.
5. What is the frequency of the $n=2, \ m=1$ mode? How does this compare to the fundamental frequency? Is this a harmonic? How do you know?
6. Now look at the $n=1$ and $m=2$ mode and describe the motion in the surface and 3D view. What is the frequency of this mode? How does this compare to the $n=2$ and $m=1$ mode frequency? This is an example of ***degeneracy***; two different modes end up with the same frequency because of the symmetrical nature of the system.
7. Look at the $n=2$ and $m=2$ mode. For a slice in the x-direction a quarter of the way up the y-axis, what string mode does this look like?
8. Where are the nodal lines for the $n=2, \ m=2$ mode?
9. What is the frequency of the $n=2, \ m=2$ mode? How does this compare to the $n=2$ and $m=1$ mode frequency? Is the $n=2, \ m=2$ mode a harmonic?
10. Now look at other pure modes by choosing the custom button, selecting n and m, 'enter' and 'add'. To change to a different pure mode, click reset before each 'add'. Try to find other cases of degeneracy. Which combinations of n and m are degenerate?
11. Find the number of anti-nodes in the x-direction and in the y-direction for the $n=3$ and $m=2$ pure mode (don't forget to click reset before adding the values of n and m).
12. Describe the nodal lines for the $n=3$ and $m=2$ pure mode.
13. If you do NOT click reset before adding a mode, the mode gets added to whatever modes are already present on the surface. Add the $n=1$ and $m=1$ mode to the $n=2$ and $m=2$ mode. Describe what you see in the surface view and the 3D view.
14. Add several higher modes (don't hit reset in between). What is the effect of having lots of different modes on the surface at the same time?