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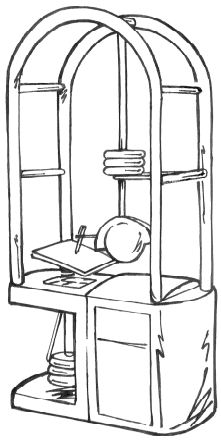
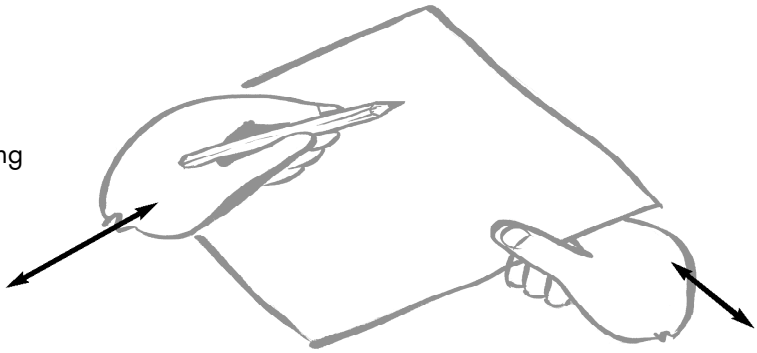


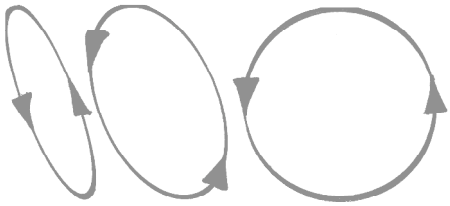
Harmonograph

What to do: Make sure the pen is raised (check by pressing the button) and clip a clean piece of paper on the table. Set both pendulums swinging and press the button to lower the pen.

HOW IT WORKS

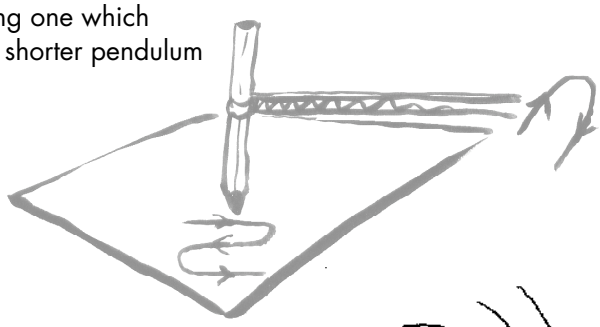
1. The arrangement is rather like someone drawing on a sheet of paper that is being moved by someone else.

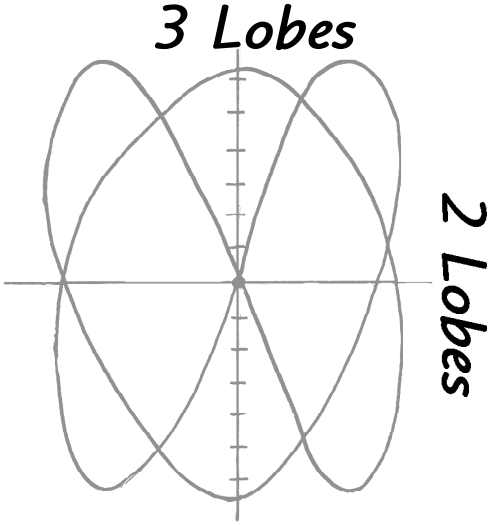




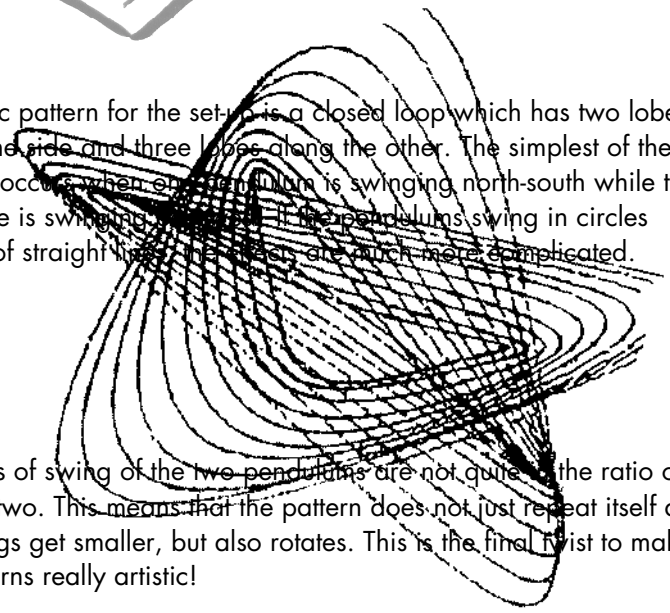
2. The simplest patterns would be produced if the two pendulums each took the same time per swing. The patterns would then either be straight lines or ellipses (*egg shapes*) or even a circle depending on whether the pendulums were swinging in step with one another or not.

3. In fact, the pendulums have different lengths; the long one which carries the pen does two swings in the time that the shorter pendulum (*which carries the table*) does three swings.





4. The basic pattern for the set-up is a closed loop which has two lobes along one side and three lobes along the other. The simplest of these patterns occurs when one pendulum is swinging north-south while the other one is swinging east-west. If the pendulums swing in circles instead of straight lines, the shapes are much more complicated.



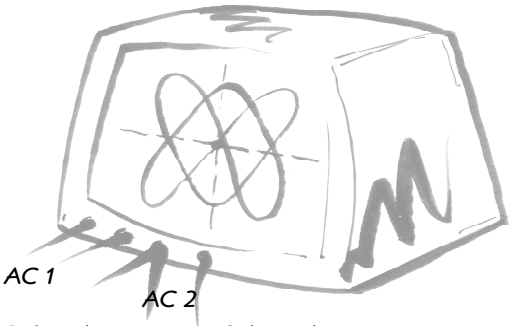
5. As the pendulums swing, they lose energy and so they swing less and less. This makes the patterns drawn by the pen get smaller and smaller, and fills in the gap that would otherwise be in the middle of the pattern.

6. The times of swing of the two pendulums are not quite in the ratio of three to two. This means that the pattern does not just repeat itself as the swings get smaller, but also rotates. This is the final twist to make the patterns really artistic!

A BIT MORE TECHNICAL

- The simple patterns drawn by two pendulums swinging at right angles to one another are called Lissajou Figures, after the French scientist, Jules Lissajou who first investigated them in the mid - 19th century.

- The patterns can also be produced electrically, using two alternating currents instead of two pendulums. In this case, the pattern is produced on a TV screen or by moving a beam of light with two mirrors which are vibrating in time with the electric currents.

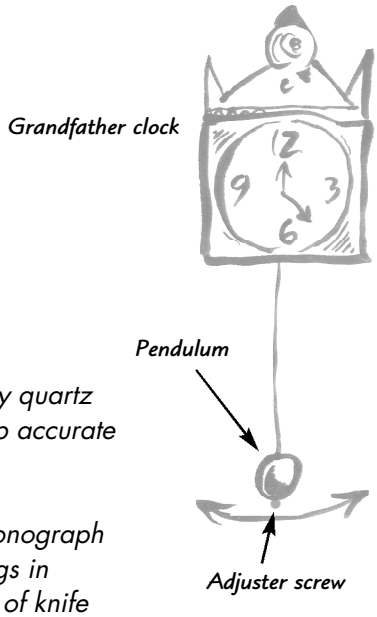


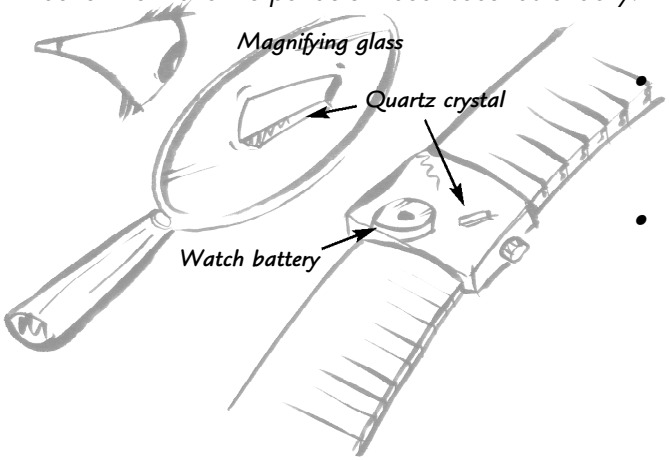
- Before the invention of clever electronic instruments, Lissajou figures were used for measuring the frequency of alternating currents (frequency means how many times the current reverses its direction in one second).

- If you know the frequency of one of the currents, you can produce a Lissajou figure and count the number of lobes along each side of the pattern to calculate the other.

DID YOU KNOW?

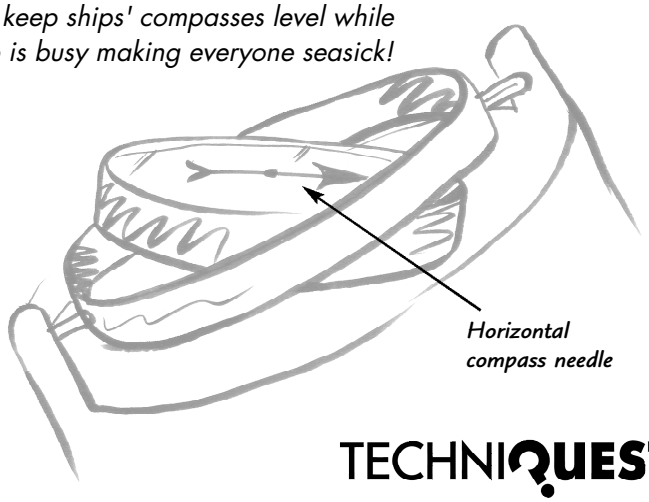
- *The time taken for a pendulum to make one complete swing depends on its length. A pendulum about 1 metre long takes about 2 seconds to swing to and fro, and this length was used in old fashioned grandfather clocks to keep time.*
- *Slight adjustment of the length is necessary with a screw at the bottom to make the pendulum beat seconds exactly.*





- *These days, the vibrations of tiny quartz crystals are used instead to keep accurate time.*

- *The long pendulum in the harmonograph* (the one which carries the pen) *hangs in gimbals - a crafty arrangement of knife edges which allows the pendulum to swing north, south, east and west. Gimbals are used to keep ships' compasses level while the ship is busy making everyone seasick!*



WANT TO KNOW MORE?

- If you look at the exhibit **Laser Harmonics**, you can see all kinds of Lissajou Figures produced by a beam of laser light

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