How to explain the blood pulse to a child and the experimental measure of a gravity wave

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September 27, 2014

Abstract

We are an Engineering's Physics first course group of students in the UPC. We planned a project to explain in a simple way how the blood pulse works about the speed of a fluid in an open channel and used it.

We chose this experiment because we thought it could be a nice and beautiful experience and it goes beyond the everyday physics we study in high school (kinematics of the particle, dynamics, armonic motion. . .). It has been our first approach to the real experimental physics and it has been really a great way to develop a bit more abilities such as teamwork, literature search, experimenting (taking measures, calculating different results . . .) and, above all, thinking.

First of all, we have studied this phenomenon. When our heart beats, it boosts the blood through our arteries. We can easily measure the frecuency of the pulse, which is a mechanical wave produced by the heart in this process. However, the blood travels at a really lower speed: we have a fluid in a channel that moves slower than the wave that propagates by it (actually,

Figure 1: The attraction.

the blood pulse does not propagate by the blood but by the arterial wall, so we will only be able to explain this as a metaphor since we will make our experiment with a wave that travels by the moving fluid).

The Alaska attraction, in the Tibidabo amusement park, can be used to easily explain people how the blood and the pulse work. There is an open channel with a certain level of water and little boats where children sit. The fluid moves and makes the boats move. When the boat falls down from the ramp, it provokes a mechanical wave that propagates by the water (gravity wave). So we have two speeds: the one of the liquid (v_1) and the one of the pulse (v_p). When we measure them, we find that $v_1 = 0.25$m/s (approximately) and $v_p = 2.17$m/s. However, since the fluid is moving, v_p is not the real velocity of the wave: $v_p = v_1 + v_2$, where v_2 would be the speed of the pulse if the fluid was resting. Then we have $v_2 = 2.17 - 0.25 = 1.92$m/s. The velocity of a gravity wave in shallow liquids is given by the expression[1]

$$v = \sqrt{gh} \tag{1}$$

where g is the acceleration of gravity and h is the distance between the surface and the bottom of the channel. If we calculate it using this formula ($g = 9.8\text{m/s}^2$ and $h = 0.38$m), we get $v_2 = 1.93$m/s, so we demonstrate that this expression is completely valid for our phenomenon: a gravity wave in a shallow liquid.

In order to study the properties of the wave, we used a few masses (corks) hooked in a long rope, each one separate 50 centimeters. That tool helped us to distinguish the wave's profile and make the analysis.

Wave analysis

To carry out the wave analysis, the rope was recorded using an slow-motion camera. Later on, a tracking program was used, so that it let us follow the place where the different masses were in each of the frames. Using that information, an animation that represented the wave was created and used to find out the data that has been shown in the article.

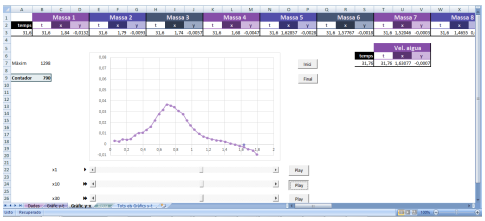

Figure 2: The wave simulation. Author: Guasch Morgades, Maria

[1]From: ves.cat/l0Fn and ves.cat/l0Fo ("Ondas superficiales de gravedad").