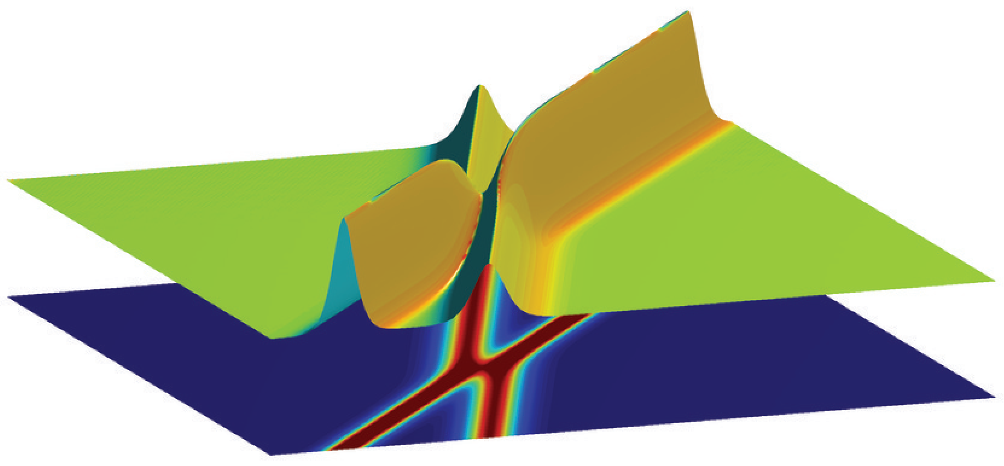


How to create your own Tsunami?

Kent's Topological Soliton Group

John Scott Russell

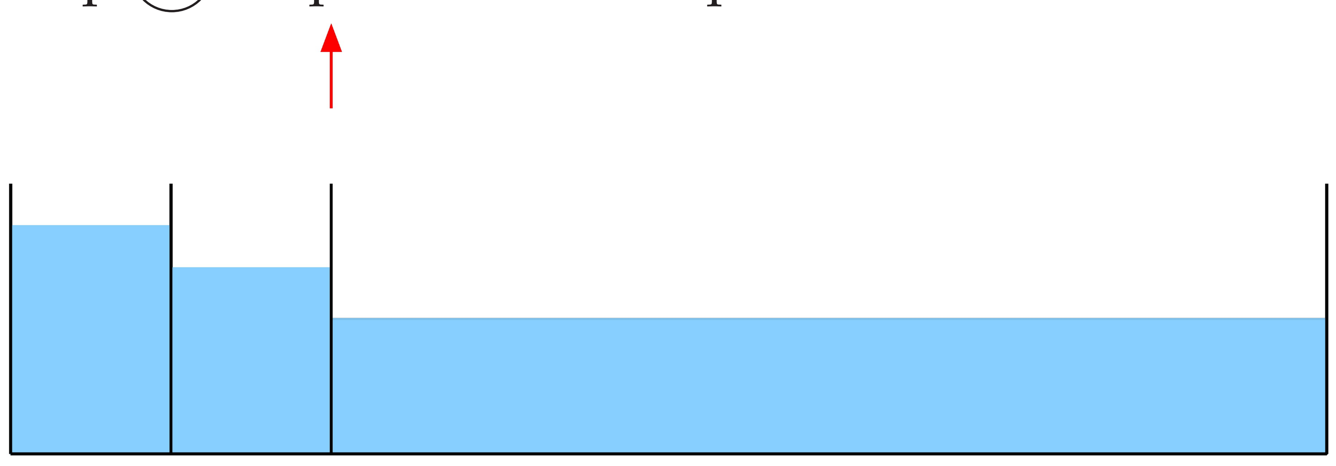
In 1834, John Scott Russell, a Scottish naval engineer, was riding horseback along a canal when he made a remarkable discovery. He saw that a passing boat had created a very unusual wave. When recreating these waves in long tanks he observed the following properties:

1. The wave kept on moving without losing speed or altering its shape.
2. The wave's speed depends on its height.
3. If two such waves collide they pass through each other and emerge from the collision unchanged.

Nowadays, this type of wave is called a *solitary wave*. The giant waves known as tsunamis share a lot of the properties of solitary waves. Typically created by underwater earthquakes they travel ashore over very long distances (up to 500 miles) whilst loosing very little energy.

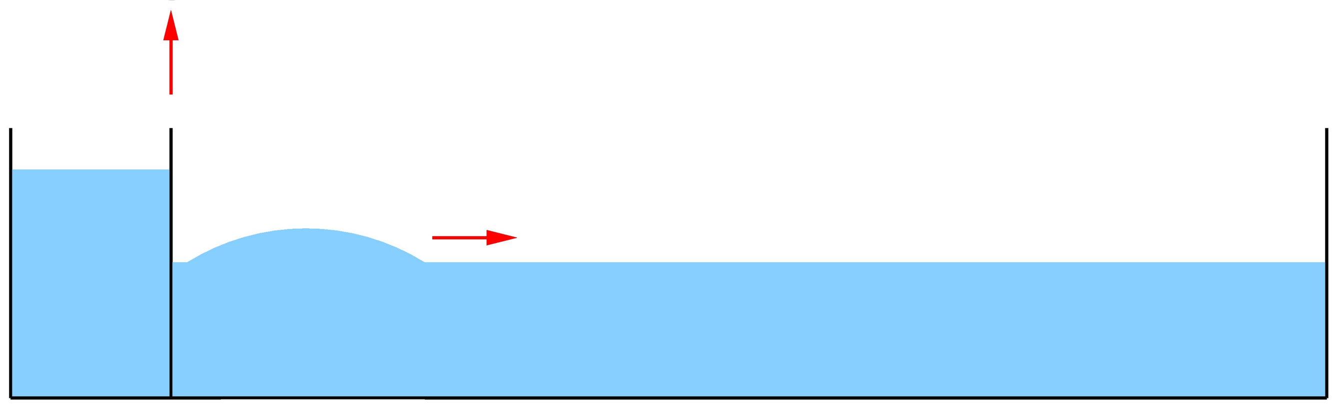
How to create your own solitary wave

Step (1): Experimental Setup



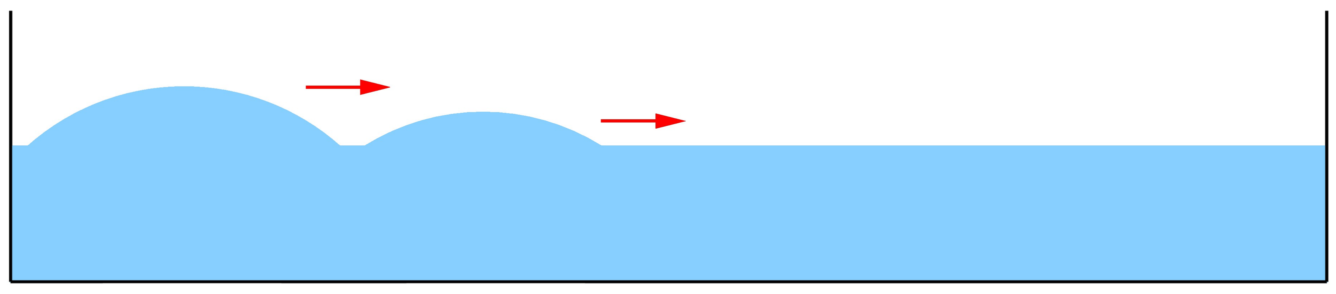
We begin with the two shutters closed and fill the two reservoirs with different levels of water. The first reservoir contains a higher level of water than the second one.

Step (2): Create first wave



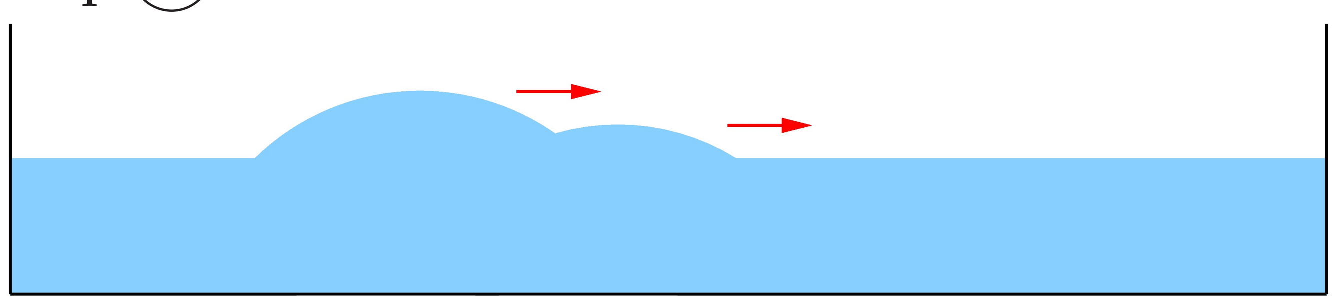
We remove the second shutter. This creates a solitary wave travelling at constant velocity towards the end of the water tank.

Step (3): Create second wave



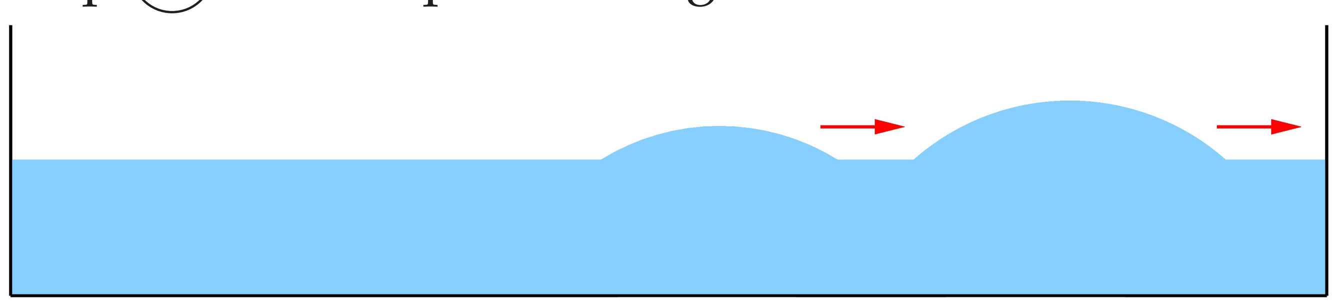
We remove the first shutter. This creates a larger solitary wave travelling at higher velocity. It follows the previously created wave.

Step (4): Wave collision



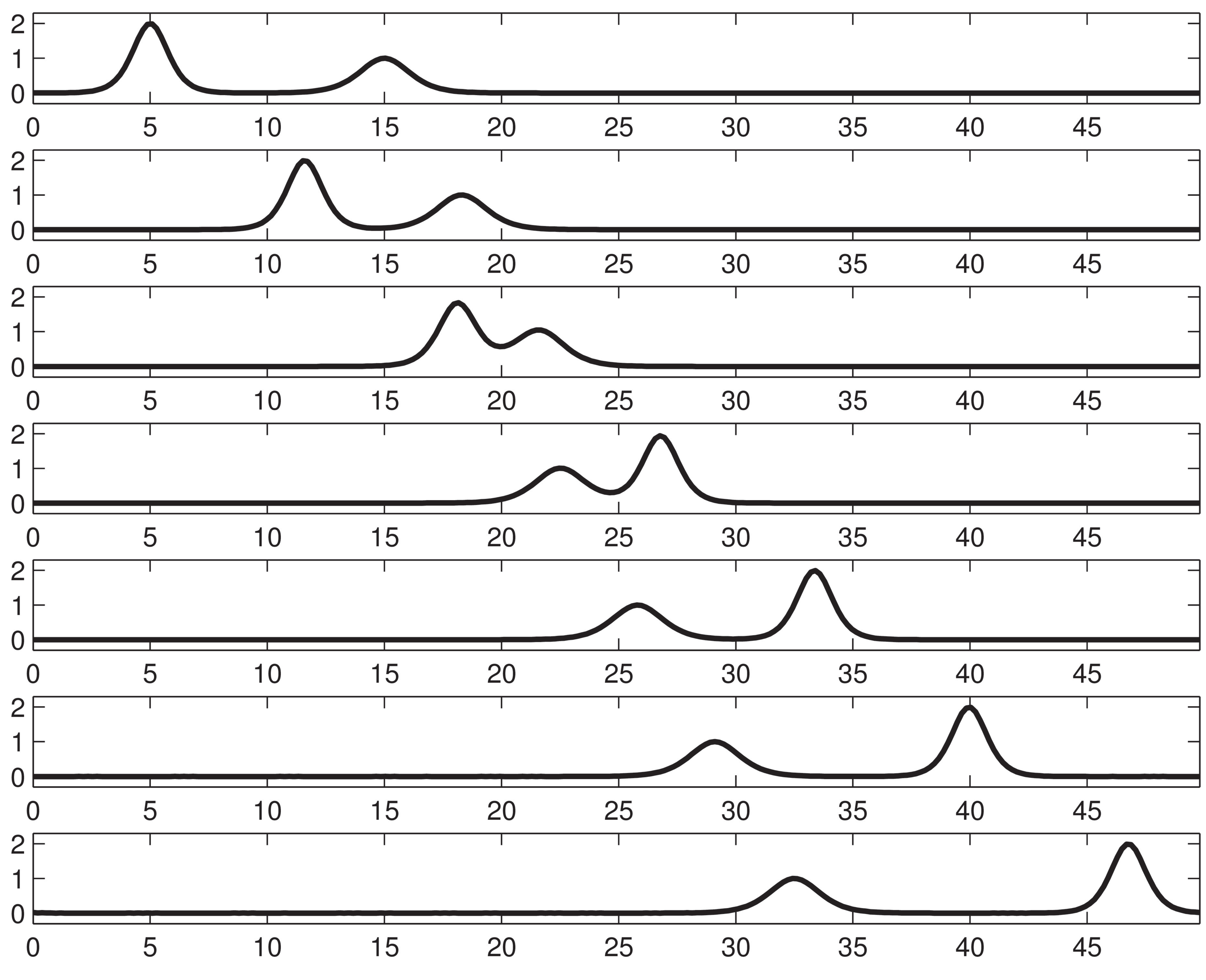
As the larger wave travels faster, it catches up to the smaller wave which travels at a slower velocity. We see them combining.

Step (5): Waves pass through each other



Finally, the larger wave overtakes the smaller. We observe that both waves are unchanged by the collision and continue at their original velocities.

Solitary Waves in Theory



We understand the dynamics and properties of these solitary waves using mathematics. We simulate these phenomena with the Korteweg-de Vries (KdV) equation. This equation models shallow water waves such as those observed in our water tank experiment. The figure on the left shows the process of a larger wave overtaking a smaller one as it occurs in the KdV theory. It is illustrated through snapshots taken at different times. We observe that these pictures encapsulate the behaviour of the water waves from our experiment.

The height of the wave is a measure of its speed. The taller wave travels faster than the smaller wave. This enables the larger wave to overtake the smaller one. For normal water waves there is the *principle of superposition* which tells us that when colliding waves merge and their total height is given by the sum of their original heights. However, as we have seen, solitary waves do not satisfy the principle of superposition. They interact in an intriguing way.