



## Flowing solids

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### Introduction:

The granular material includes all materials which are composed by separate solid particles of any size. Some examples of granular material are: coffee, sand, rice, salt, wheat, sugar. Despite its apparent simplicity, the granular material has a mysterious and surprising properties which are very difficult to interpret due to the lack of physical models.

Small differences in either size or density lead to flow-induced segregation, a complex phenomenon without parallel in fluids. In Particle Segregation particulate solids tend to segregate by virtue of differences in its size, density, shape and other properties related to the composition of these particles.

### Objectives:

An experiment to show one of the most striking properties of granular matter will be proposed: segregation

### Material:

#### a) Construction of two-dimensional structure

- 2 methacrilat layers plate (in this experiment, 33 cm wide and 24 cm high)
- 2 wood strips (23 cm x 1 cm)
- 1 wood strip (33 cm long and 1 cm wide)
- 2 strips of wood that will form the basis
- 4 clips
- Some carpenter's glue



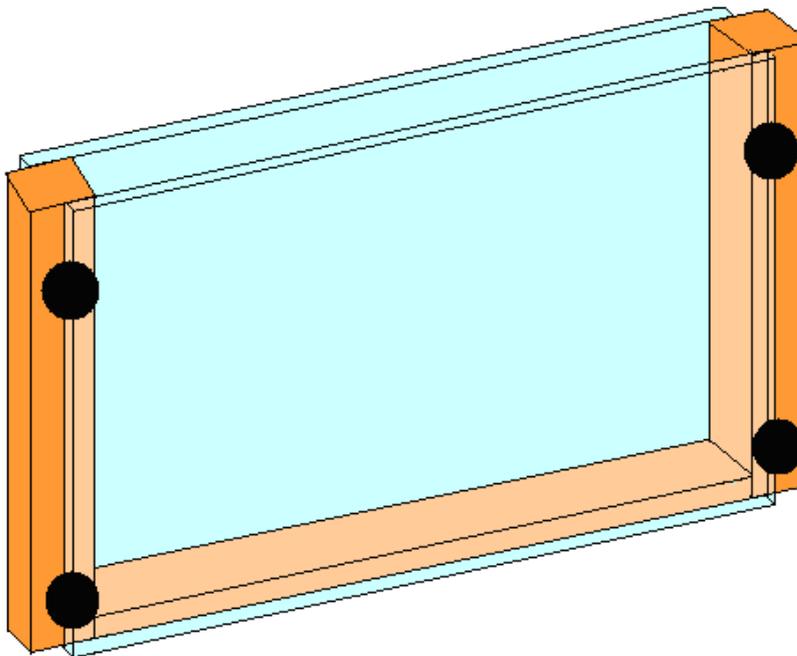
Picture 1. Materials to construct two-dimensional structure

**b) In addition, you need**

- A funnel
- Drinking bottle (1 liter minimum)
- Granular Matter: sand, salt, feed

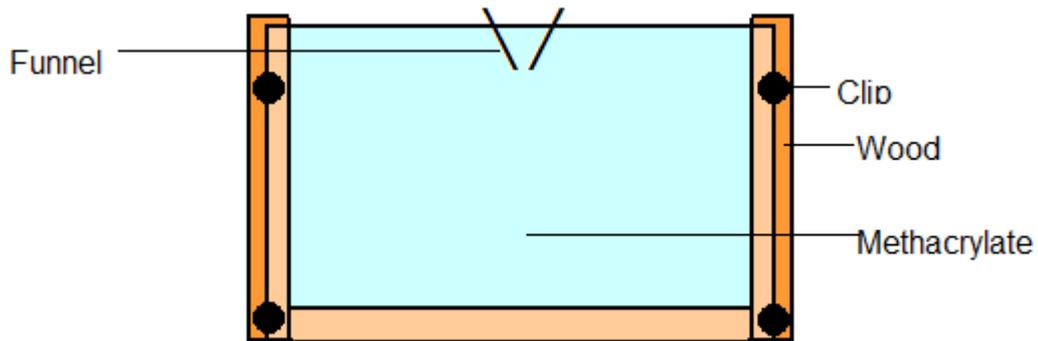
**Procedure:**

1. Build a two-dimensional structure using carpenter's glue, wood, the 2-methacrilat layers plates and clamps (Picture 2)



Picture 2. two-dimensional structure

2. Fill the bottle with a mixture of salt and feed (Picture 3)
3. Shake the bottle and empty it into the two-dimensional structure using the funnel
4. Notice how the materials are deposited
5. Repeat the process using a mixture of salt and sand



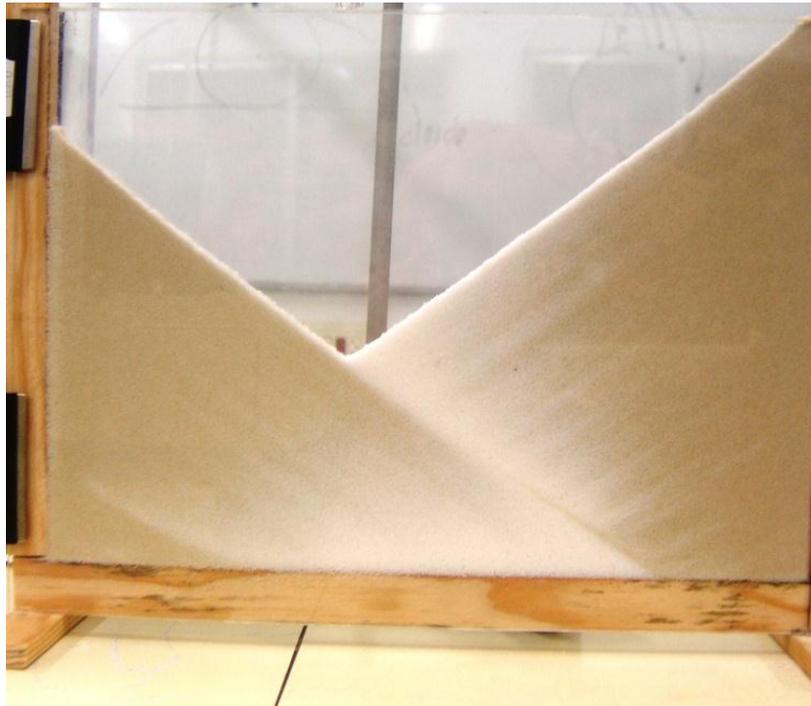
Picture3. Experimental design to study the segregation of a mixture of granular materials

### What's happens?

The images 4 and 5 show us the results of the experiment.



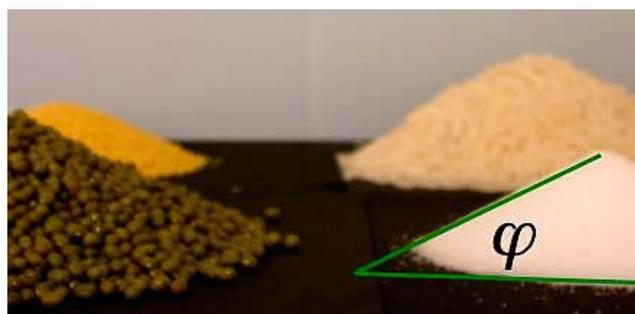
Picture 4. Segregation of the salt-feed mixture. The salt is separated from the feed



Picture 5. Segregation fo the sand-salt mixture. The sand is separated from the salt

### **Professional explanation:**

It is very difficult to justify the properties of granular materials. One possible explanation about the segregation is related to the "angle of repose " (Picture 6) Every granular material has its characteristic angle of repose( $\phi$ ). This angle depends on the density of the material and the degree of compaction. The higher the density of the granular material is bigger the angle of repose. For example, the angle of repose of the salt is greater than the feed, and the angle of repose of the sand is greater than the salt. Disparity of the angles of repose among different particles causes segregation. Particles deposited with greater angles of repose form a steep pile under the deposition point while the ones with lower angle of repose roll away from that point.



Picture6. Angle of repose