MCEN 4151
Flow Visualization

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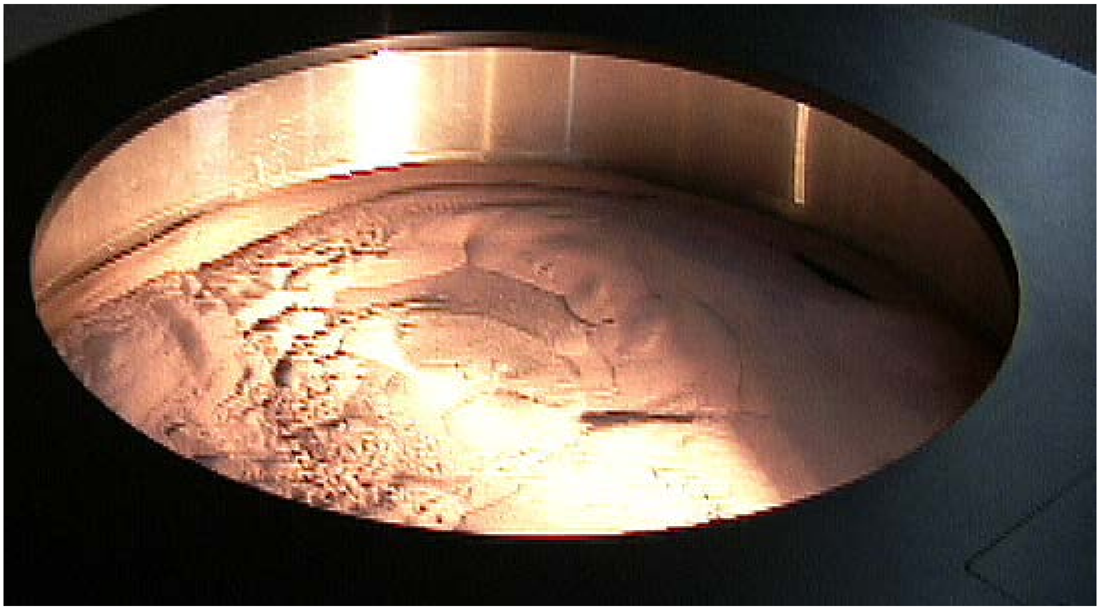
Assignment #1: Get Wet

Introduction

The image shown above is a screen shot taken from a video, which explains the less than stellar quality. The original video was not done in a team setting. The intent of the video was to show how grains can behave like fluids, or granular flow. It is important to note that although sand in this case behaves *like* a fluid, it is by definition *not* a fluid, as small continuous shear forces will not continuously deform the sand. The sand is placed in a vibration table, and the vibrational frequency is adjusted until the desired effect is shown. The apparatus has a one minute run cycle, so multiple takes were necessary. The final video shown above shows the effect most clearly. An underlying effect to be discussed later is known as Chladni patterns, although this video does not accentuate this effect.

Setup

The image below depicts the setup used. The video camera was attached to the tripod, and subsequently placed onto the tectonic table. The controls were used to adjust the vibrational frequency until the desired effect was seen.



The inner diameter is approximately 4', with an outer diameter of approximately 6'.

The granular flow effect in the video is caused directly by vibration. When the table vibrates, it causes microcosms of air between each particle of sand, allowing gravity to move the particles. Under static conditions (no vibration), the particles behave just as one would expect. Frictional, normal, and gravitational forces all cancel each other out due to Newton's Second Law. However, the air pocket causes each particle to break contact with neighboring particles, nullifying frictional and normal forces, thus allowing gravitational forces to enact an acceleration on the particle. The directionality of flow is likely due to Chladni patterns, as well as a non-uniform flatness in the platform.

This effect does not explain why the larger sand mounds do not move due to vibration. This occurs because of increased pressure from the sand above the tabletop. The pressure does not allow a break in contact between particles near the tabletop surface. Furthermore, the force enacted on the sand particles is dispersed evenly throughout the mound, and so the top layer does not experience a break in contact with the layer below it.

Another effect is occurring, although it is not clearly visible in this video. Chladni patterns can be seen when a fluid flows over a vibrating area. By definition, vibration is an oscillation around equilibrium. As can be expected, this oscillation features peaks and nodes, with predictable positions based on the frequency of vibration. Due to gravity and conservation of energy, the fluid will tend to settle into these nodes. These patterns are called Chladni patterns because the first person to observe and quantify them was Ernst Chladni.

Technique

No special techniques were employed. The lighting was done by the tectonic table itself, shined perpendicular to the field of view and across the table.

Camera Technique

FOV size: unknown. This will be known in future publications.
Distance from object to lens: 4 feet
Lens Focal Length: unknown.
Digital camera: Sony CyberShot DSC-W690, 640 width by 480 height
No post-recording processing

The lens focal length is unknown because this particular camera model does not allow focal length adjustment while recording video. The camera adjusts it automatically for focus.

Intent and Assessment

This video, while not revealing Chladni patterns, very clearly depicts the tendency for a large number of small particles to behave like a fluid. I fulfilled my intent in showing this effect. I like how well the effect is shown, however the chosen camera does a poor job of auto-focusing while taking videos. If I were to repeat this experiment, I would choose a camera more suitable for video.