

INSTRUCTOR NOTES

1st video (“training” video)

- The first video is an opportunity to observe and to express observations in words.
- My student written responses varied greatly, from almost nothing, and in language that was difficult to decode, to extensive, articulate, notes
- My student estimates of the angle, from simply visually looking at the projector screen, varied wildly. See my observations and data (below).
- The guessing of the angle of a slope is in itself instructive, especially when its wrong.
- The actual angle can be measured on a printed image (below)
- Ideas about how to measure quantitatively (pile height, width) will vary widely. Some students will use the ruler in the background, some won't notice it.
- I teach two sections of ES101. In the first section, I did NOT ask students to sketch an outline of the pile (question #4). It is interesting that of 21 students, only 2 sketched on their own without prompting. See their sketches in the next section. In the second section, I changed the question to explicitly request a sketch. See these sketches also in the next section.
- I've included all student sketches (below). You can see interesting variation in fidelity and artistic license.

2nd video (“assessment” video)

- As students observe the completed pile of the 1st volume of sand, they are asked to make predictions about changes that would take place when a second volume of sand is allowed to accumulate on top of the first pile. What I wanted to accomplish is to have students assess whether or not their predictions were accurate (and hope that some were not, as learning is best when a mistake is made).
- However, I sort of screwed up this part. I recognized too late that as students watched the second pile build on top of

the first, some went back up the column, and I'll bet they wrote in a “predication” after the fact of observing. I'm not sure how to guard against this “cheating” without having them write predictions on a separate piece of paper that they fold up on their desk, or even hand in for collection, prior to watching the second video. Any suggestions? Maybe nothing to really worry about?

Some interesting observations that can be used for simple or more detailed discussions.

- Slope angle remains approximately constant – why?
- Mechanics of sand motion dropped onto pile from circular and centered tube includes the formation of a radial pile due to radial distribution of sand exiting the bottom of the circular cross-section of the tube (in a horizontal plane, this approximate shape would be called a binormal distribution, two normal distributions at right angles forming a mound circular in horizontal cross-section and normal in a vertical section).
- Although we may assume sand grains fall evenly on the surface of the pile, you can observe limited sections of the surface move downward like a miniature landslide (chaotic slumping).
- The position of these slumps seems to occur irregularly from place to place on the part of the pile that faces us in the video, although I observe they are more likely to be located in adjacent pairs.
- More importantly is an explanation for the cause(s) of these slumps. Slumps occur where sand builds to an angle greater than that which can be supported by friction among the grains. Then gravity overcomes friction and the section slumps, reestablishing the natural “angle of repose”. I consider this analogous to river delta avulsion, when the main channel chaotically seeks another direction to sea level that is of a higher slope due to a shorter path.
- Some students predict that the equal volume of sand would increase the height of the pile to at least 1.5 times its height of the first (which can be estimated from the ruler mounted vertically in the background). A few

students said that the second volume of sand would double the original height. You can observe that the height only increases from about 20 mm to about 25 mm, or about 20%.

- I hadn't designed it this way, but it is interesting that when I positioned the bottom of the rubber tubing (arbitrarily but not too far above the base), and I had chosen the volume of sand to drop, I didn't anticipate that the second volume, if it actually were to double the height of the pile, would rise above the level of the bottom of the rubber tubing. In fact, one student anticipated that potential result, and said that the height of the pile could not exceed the height of the bottom of the tubing. And this is correct. If there were enough sand accumulating on top of the pile to actually reach the bottom of the tubing, then the sand would stop falling, as the column of sand would now resting on the pile against the ground would stop the flow through the tube by frictional resistance. Very nice, but I can't take a priori credit for this idea. And a really good point that only a few students might come up with.

I'm sure you can think of many more interesting aspects for student engagement, discussion, and analysis that these two videos might be used to develop. I normally operate under the assumption that the more general and fundamental phenomena are the most productive of creative ideas and critical thinking.

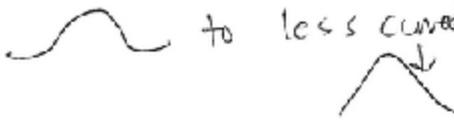
How many different "exercises" can be generated from these videos?

Looking forward to your contributions!

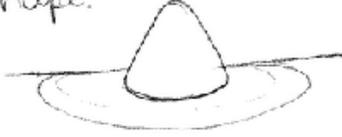
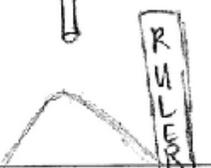
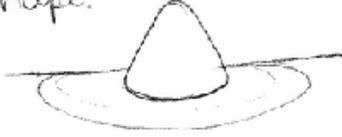
A generic copy of the exercise will be available on the website for use and modification as needed.

Scott Brande

First section (n=28) – Instructions to sketch were not explicitly mentioned. Only 2 of 28 students sketched.

<p>4. Describe the shape of the pile as it builds – does the pile change shape, or not? Describe.</p> <p>angle of pile stays the same. Base + height grow.</p> 	<p>4. Describe the shape of the pile as it builds – does the pile change shape, or not? Describe.</p> <p>Shap goes from curved to less curved</p>  <p>Becomes more point, triangle like and is so bulky & round like</p>
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Second section (n=22). Sketch explicitly requested.

<p>5. Describe the shape of the pile as it builds – does the pile change shape, or not? Also, sketch a cross-section of the final pile.</p> <p>A pyramid of triangles, there is a base around it where the grains of sand unable to stay on top in pile accumulate.</p> 	<p>5. Describe the shape of the pile as it builds – does the pile change shape, or not? Also, sketch a cross-section of the final pile.</p> <p>similar shape throughout.</p> 	<p>5. Describe the shape of the pile as it builds – does the pile change shape, or not? Also, sketch a cross-section of the final pile.</p> <p>It does not change shape</p> 
<p>5. Describe the shape of the pile as it builds – does the pile change shape, or not? Also, sketch a cross-section of the final pile.</p> <p>Shape remains constant</p> 	<p>5. Describe the shape of the pile as it builds – does the pile change shape, or not? Also, sketch a cross-section of the final pile.</p> <p>It builds almost as if it were an Ant Bed no, it does not change shape</p> 	<p>5. Describe the shape of the pile as it builds – does the pile change shape, or not? Also, sketch a cross-section of the final pile.</p> <p>Originally it was a bit more angular, but as it reached its maximum height it stayed consistent</p> 
<p>5. Describe the shape of the pile as it builds – does the pile change shape, or not? Also, sketch a cross-section of the final pile.</p> <p>sketch remains in form of a pyramid</p> 	<p>5. Describe the shape of the pile as it builds – does the pile change shape, or not? Also, sketch a cross-section of the final pile.</p> <p>Dome shaped. Pile does change shape. Becomes taller overtime</p> 	<p>5. Describe the shape of the pile as it builds – does the pile change shape, or not? Also, sketch a cross-section of the final pile.</p> <p>pile does not change shape</p> 
<p>5. Describe the shape of the pile as it builds – does the pile change shape, or not? Also, sketch a cross-section of the final pile.</p> <p>it is in a rounded cone shape.</p> 	<p>5. Describe the shape of the pile as it builds – does the pile change shape, or not? Also, sketch a cross-section of the final pile.</p> <p>pile does not change shape</p> 	<p>5. Describe the shape of the pile as it builds – does the pile change shape, or not? Also, sketch a cross-section of the final pile.</p> <p>pile does not change shape</p> 

5. Describe the shape of the pile as it builds - does the pile change shape, or not? Also, sketch a cross-section of the final pile.

Dome, becomes more and more rounded on top.

5. Describe the shape of the pile as it builds - does the pile change shape, or not? Also, sketch a cross-section of the final pile.

~~It changes shape~~
It becomes a larger
It gets taller in the middle portion

5. Describe the shape of the pile as it builds - does the pile change shape, or not? Also, sketch a cross-section of the final pile.

round bottom round top

5. Describe the shape of the pile as it builds - does the pile change shape, or not? Also, sketch a cross-section of the final pile.

The piles builds up into a figure more similar to a pyramid

5. Describe the shape of the pile as it builds - does the pile change shape, or not? Also, sketch a cross-section of the final pile.

dome → triangle, volcano like

5. Describe the shape of the pile as it builds - does the pile change shape, or not? Also, sketch a cross-section of the final pile.

- becomes pyramidal but started off more oval shape

5. Describe the shape of the pile as it builds - does the pile change shape, or not? Also, sketch a cross-section of the final pile.

like a pyramid. No volcano.

5. Describe the shape of the pile as it builds - does the pile change shape, or not? Also, sketch a cross-section of the final pile.

yes, it becomes a more pointed hill as more sand falls.

5. Describe the shape of the pile as it builds - does the pile change shape, or not? Also, sketch a cross-section of the final pile.

its a pyramid shape does not change shape

My failure of anticipated lack of student understanding

Instructions to students on the handout included the following (Part I, #2):

2. Estimate the angle (in degrees) of slope of a side of the pile after it is built _____.

I anticipated that students would view the image (below), and be able to reasonably estimate an angle of repose between, say, 25 and 60 degrees. I measured almost exactly 35 degrees on the image.

It was my failure to anticipate that a significant fraction of students failed to properly estimate the slope angle. I consider angles greater than about 60 significant failures. There are a number of possible points of student misunderstanding, including (among probably many other alternatives),

- not understanding the concept of an angle,
- not correctly applying their concept of an angle to the image,
- incorrectly identifying the two sides of the angle for measurement,
- incorrectly locating the point of origin of the correct angle, or,
- ???

Fig. 1. Frequency Distribution of Student Estimates of Angle of Repose (degrees).

However, students saw only the image on the video, not my overlay of the angle sides or other annotation, as in Fig. 2.

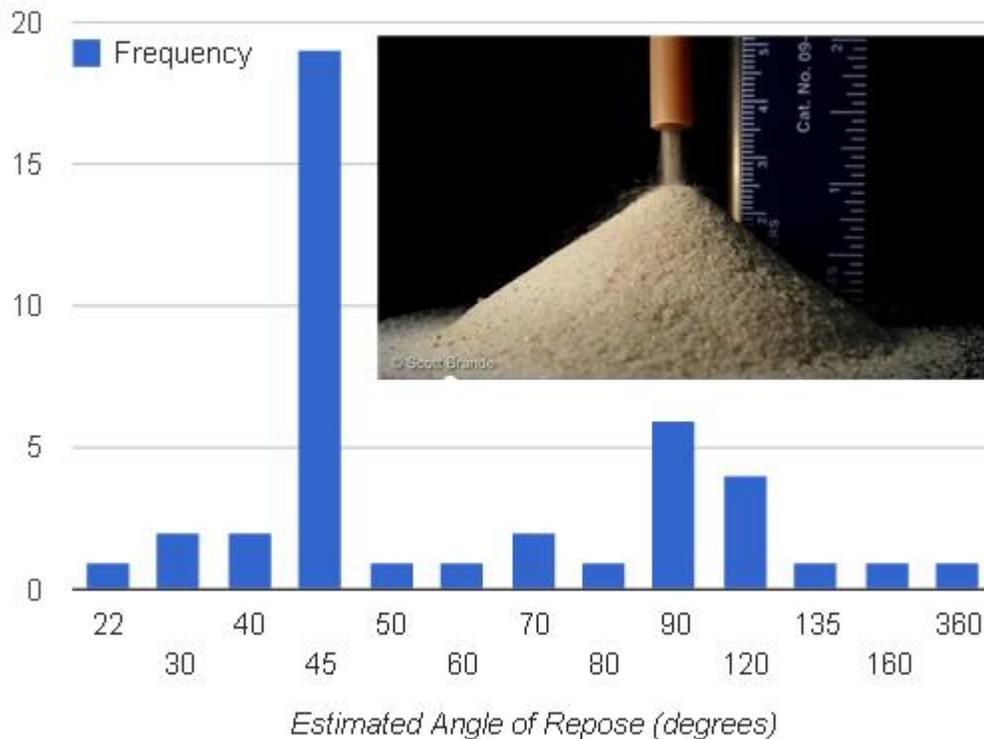


Fig. 1

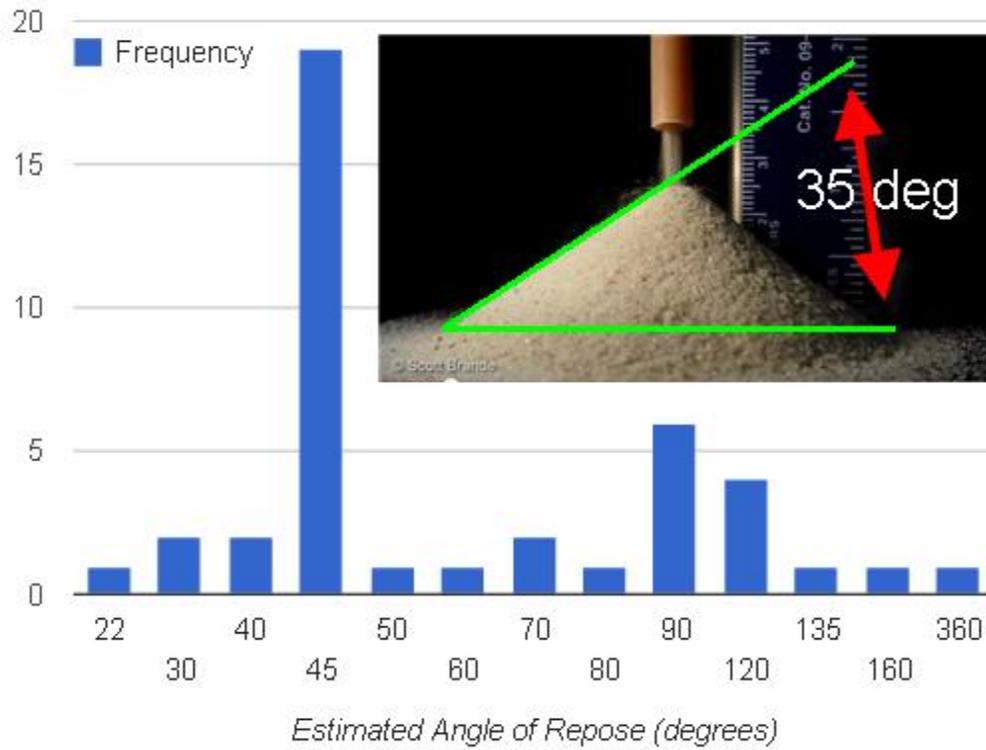


Fig. 2 – Data with approximate answer overlay.